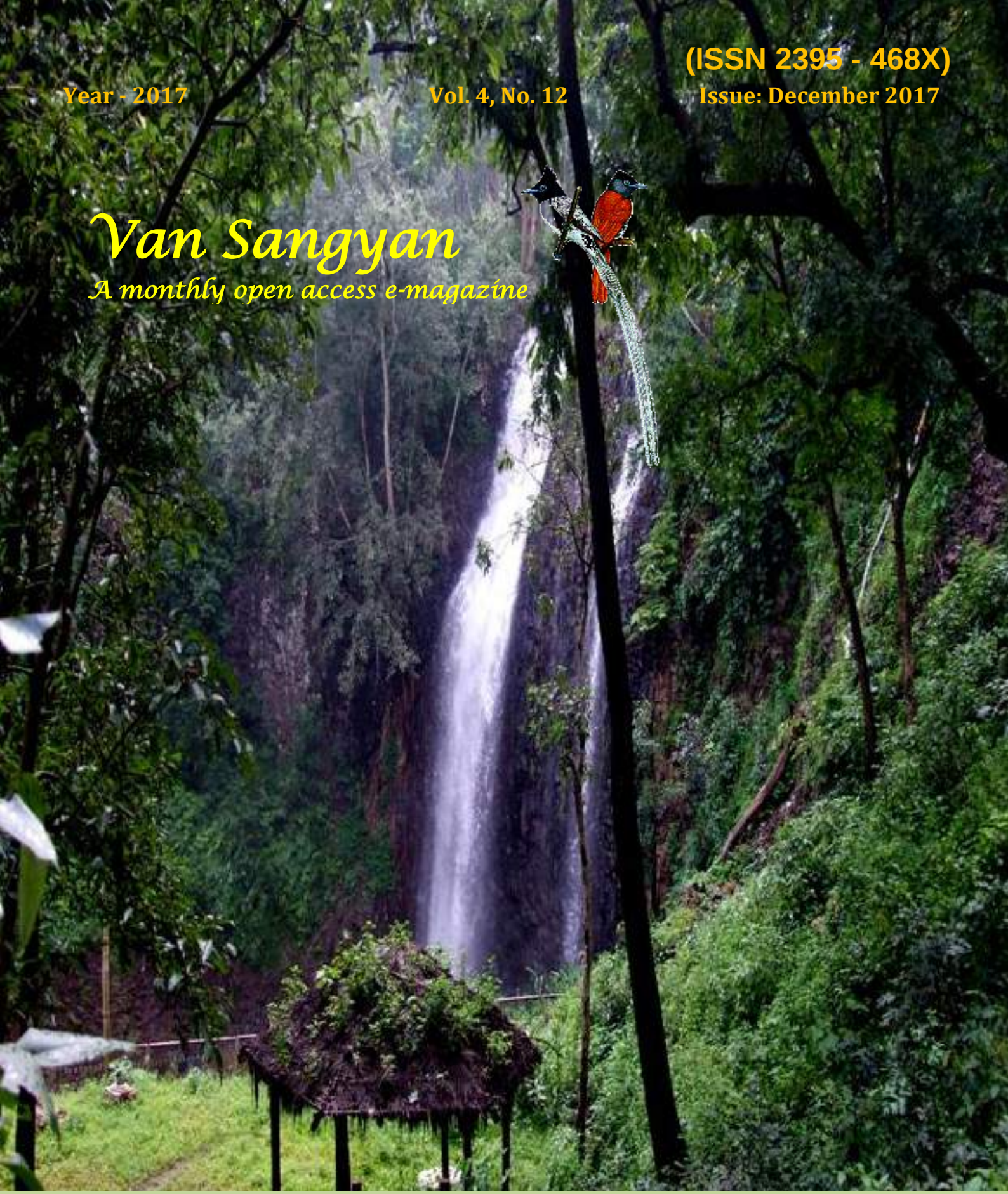
(ISSN 2395 - 468X)
Year - 2017 Vol. 4, No. 12 Issue: December 2017



Van Sangyan

A monthly open access e-magazine

Indexed in:

COSMOS Foundation (Germany)

International Inst. of Org. Res. (Australia)

Tropical Forest Research Institute
(Indian Council of Forestry Research and Education)
Ministry of Environment, Forests and Climate Change (MoEFCC)
PO RFRC, Mandla Road, Jabalpur – 482021. India

Van Sangyan

Editorial Board

Note to Authors:

We welcome the readers of Van Sangyan to write to us about their views and issues in forestry. Those who wish to share their knowledge and experiences can send them:

by e-mail to vansangyan_tfri@icfre.org

or, through post to The Editor, Van Sangyan,
Tropical Forest Research Institute,
PO-RFRC, Mandla Road,
Jabalpur (M.P.) - 482021.

The articles can be in English, Hindi, Marathi, Chhattisgarhi and Oriya, and should contain the writers name, designation and full postal address, including e-mail id and contact number.

TFRI, Jabalpur houses experts from all fields of forestry who would be happy to answer reader's queries on various scientific issues. Your queries may be sent to The Editor, and the expert's reply to the same will be published in the next issue of Van Sangyan.

Cover Photo: Panoramic view of Achanakmar-Amarkantak Biosphere Reserve
Photo credit: Dr. N. Roychoudhury and Dr. Rajesh Kumar Mishra, TFRI, Jabalpur (M.P.)

From the Editor's desk

We depend on forests for our survival from the air we breathe to the wood we use. Besides providing habitats for animals and livelihoods for humans, forests also offer watershed protection, water, food/fuel security, prevent soil erosion, shelter and mitigate climate change. Amongst all the above, some are easy to figure out - fruits, paper and wood from trees, and so on. Others are less obvious to figure out that their source is forests, such as by-products that go into everyday items like medicines, cosmetics, detergents and many such non-timber forest products (NTFPs). Looking at it beyond our narrow, human – not to mention urban – perspective, forests provide habitats to diverse animal and plant species. They are home to 80% of the world's terrestrial biodiversity. Besides other biota, they are home to 300 million people including 60 million indigenous people. Despite all above, between 1990 and 2015, the world has lost some 129 million ha of forest, an area the size of South Africa. When there is destruction of the forest, it is not just the trees that are destroyed. Rather, the entire ecosystem begins to fall apart, with dire future consequences for all of us, in addition to their important role in protecting the fragile environment, they provide variety of goods and services. In modern day, realization of forests as carbon sink, carbon locking in the form of timber for years and years have wide opened scope for further discussion on whether to follow pure conservationist approach or to go commercial by increasing productivity with sustainable management. This is particularly true for some countries which have their forest management system based on the concept of conservation as priority.

While all forests are source of useful products but this has to be a sustainable production by keeping the forests healthy, protected wildlife habitat, continually replanted and more. In this way sustainable supplies are required to be ensured by the forest managers/owners, for the future. However, role of the society particularly those inhabiting the forest areas, is of prime importance in protecting and sustainably managing the forests to ensure its availability for the next generation. *This is possible only by educating the society on the above aspects so as to secure healthy future of the world's forests and in turn the human beings, through popular scientific articles in easy to understand international, national and/or regional languages.*

In line with the above this issue of Van Sangyan contains an article on Value chain analysis of forest wood products. There are other useful articles viz. Carbon sequestration in forest ecosystem and methods for its evaluation, Lannea coromandelica – A potential multipurpose tree for industrial agroforestry, Water management in vegetable crops for higher productivity, Diversity of macro-fungi in central India-X: Edible mushrooms Macrocybe crassa and Macrocybe lobayensis, प्रोसोपिस जूलीफ्लोरा: उत्तम काष्ठ ईंधन (in Hindi), Promotion of bamboos through agroforestry system, Heavy outbreak of mango leaf webber, Orthaga euadrusalis Hampson on mango trees in TFRI campus, Jabalpur, Commiphora wightti: A plant with potential healing powers and Biodiversity of Quercus ilex (Brey Oak) and Phoenicurus leucocephalus.

I hope that readers would find maximum information in this issue relevant and valuable to the sustainable management of forests. Van Sangyan welcomes articles, views and queries on various such issues in the field of forest science.

Looking forward to meet you all through forthcoming issues.

Dr. Nitin Kulkarni
Scientist G & Chief Editor

Disclaimer – Van Sangyan

Statement of Responsibility

Neither *Van Sangyan* (VS) nor its editors, publishers, owners or anyone else involved in creating, producing or delivering *Van Sangyan* (VS) or the materials contained therein, assumes any liability or responsibility for the accuracy, completeness, or usefulness of any information provided in *Van Sangyan* (VS), nor shall they be liable for any direct, indirect, incidental, special, consequential or punitive damages arising out of the use of *Van Sangyan* (VS) or its contents. While the advice and information in this e-magazine are believed to be true and accurate on the date of its publication, neither the editors, publisher, owners nor the authors can accept any legal responsibility for any errors or omissions that may be made or for the results obtained from the use of such material. The editors, publisher or owners, make no warranty, express or implied, with respect to the material contained herein.

Opinions, discussions, views and recommendations are solely those of the authors and not of *Van Sangyan* (VS) or its publishers. *Van Sangyan* and its editors, publishers or owners make no representations or warranties with respect to the information offered or provided within or through the *Van Sangyan*. *Van Sangyan* and its publishers will not be liable for any direct, indirect, consequential, special, exemplary, or other damages arising there from.

Van Sangyan (VS) reserves the right, at its sole discretion, to change the terms and conditions from time to time and your access of *Van Sangyan* (VS) or its website will be deemed to be your acceptance of an agreement to any changed terms and conditions.

Contents

Value chain analysis of forest wood products

A.A. Otesile, M.F. Fayiah, S. B. Mattia and A. Barrie

Department of Forestry, School of Natural Resources Management,
Njala University, Sierra Leone
E-mail: aaotesile@yahoo.co.uk

Abstract

Wood value chain analysis is a sequence of related business activities from production to consumption of wood products and the functions of the operators and supporters in the chain (GTZ, 2007). This study was carried out to identify and describe common value chains for forest wood products (sawn boards, poles, fuelwood and charcoal) in Kenema district, Eastern province, Sierra Leone. Random sampling technique was adopted for the selection of a total of 189 respondents from 10 key stakeholder groups operating in 6 key locations and communities (Serabu, Deima, Wanjama, Guala, Wuima and Waima-Topkobu). These comprised of 31 farmers, 12 chainsaw operator, 15 timber dealers, 16 transporters, 31 carpenters, 15 contractors, 9 pole producers, 19 fuelwood producers, 16 charcoal producers and 25 fuelwood sellers. Primary data was collected using structured questionnaires, interview schedule and focus group meetings, while secondary data was collected through desk study. Results indicated that, 15 species were traded in as sawn boards, 5 species as poles, 10 species as fuelwood and 15 species as charcoal. Identified wood flow channels were unique for each wood product with respect to key players involved in the value chain. Farmers were identified as the land owners who sold trees to independent contractors; who sometimes include timber merchants. Other independents also provide transportation for products at different stages of the value chain. The timber merchants often also handle retailing of respective products of choice. Market prices of each product were subject to the number of respective key player groups and processes involved in the value chainand distance from market.

Keywords: Value chain, Kenema, Wood, Market, Sierra Leone

Introduction

The value chain describes the full range of activities from conception, through the different phases of production, delivery to final consumers and final disposal after use (Kaplinsky and Morris, 2001). Value chain analysis helps to identify money flows, the bottlenecks in the chain and their causes, understand the relationships between businesses in the chain and other market players, the role of specific market functions and the rules that govern the chain (GTZ, 2007). The human population of Sierra Leone (7.07 million people) in increasing and has almost doubled in the last 11 years (Statistics Sierra Leone, 2015), but the land area remains fixed. Increase in population leads to increase in demand for land for urban expansion, food production, infrastructural development, and myriad needs for economic development (mining, agriculture, forestry, etc). Consequently, the resultant pressure for land use is negatively impacting the country's forest resources; leaving the country with less than 5% of its initial intact forest (GoSL, 2010). For example,

in the face of increasing demand, it is estimated by government that 80% of Sierra Leone's population rely on fuel wood and charcoal for their domestic energy needs; this heavy dependence on the nation's forest for domestic energy needs is thus massively diminishing the remaining forest estate in the country. It therefore becomes imperative to mobilize activities; not only to establish new forests or plantations, but to ensure the sustainable management ofthe country's forest estates. Value chain analysis of commonly exploited wood products is therefore an effective means of investigating the activities undertaken by different key players within the wood value chain.

Since value chain denotes a set of agents, with related activities and markets; contributing directly to the production, transformation and distribution of the product to the final markets (FAO, 2009), it shows the links between the set of operators performing these functions i.e. producers, processors, traders and distributors of a particular product through various business transactions (GTZ, 2007) and represents the routine activities involved in changing inputs to outputs. Therefore, in the case of forest wood products, value chain analysis start from the forest landowner or farmer to the final consumers. Many inputs are required at the different stages of the chain. The cost of wood products hence depends greatly on the amount of inputs involved at different stages along the chain.

Due to difficulties in forecasting what assortments or quality a certain tree or stand will produce, the forest products industry is characterized by uncertainties in raw material supply. In addition there are relatively long lead-times in production; while the production process generates a relatively high percentage of consequence products (Haartveit et al., 2004). For instance, high grade firewood has the qualities of burning easily, slowly and without creating a lot of smoke; however, tree species with these qualities are not in common use or have other important uses such as fruits or wood (lumber), therefore most farmers make a compromise between quality of firewood and availability or rely on fast-growing exotic species (Amanor, 2012). In the case of charcoal, though the value chain is informal, it is quite well established with distinct production process, transportation and retail line; this notwithstanding, the value of wood used for charcoal production is not reflected in the value of the charcoal (Kituyi, 2001; ESDA, 2005; Mugo and Ong, 2006 and Sepp and Mann, 2009). Therefore, value chain analysis helps the analyst to: identify bottlenecks in the production phase and target groups who are involved in the whole chain, understand the value of each participant in the chain and how much they profit from the chain and identify the total value of the chain (Melin and Puentes, 2016).

Methodology

Study area

Kenema district lies on latitude: 7^0 50' 00" and longitude: 11^o 10' 00" and is one of the districts in the eastern province of Sierra Leone; with Kenema city as the headquarters and the third largest city in the country. The district has other major towns which include Tongo, Blama, and Yomboma. The district is the most populated in the Eastern province with a population of 609, 891 (Statistics Sierra Leone, 2015).

Kenema district has an area of 6, 053 km^2 (2,337 sq miles), consisting of sixteen chiefdoms. The district borders with Bo district to the west, the Republic of Liberia to the south, Tonkolili district and Kono district to the north, Kailahun district and Pujehun district to the East.

Kenema district has mixed economy; gold and diamond mining, as well as agricultural production of coffee, cacao and rice are major economics activities of the people. The district headquarter is an important agricultural market town and the district is the main hub of timber production and business in the country. Kenema district has tropical rainforest vegetation and two climatic seasons. The rainy season starts in April and ends in October and the dry season starts in November and ends in March. The rainfall is 2,500 to 4000 mm per year (Statistics Sierra Leone, 2015). Between June to August, the district experience heavy rainfall. The normal temperature range is 20^0C to 33^0C, although it drops as low as 10^0C at night during peak harmattan season between December and January. Day temperatures average 31^0C in the dry season and 25^0C in the rainy season.

Topographically, the district has hills, steep slope and lowlands areas. There are two major forest reserves in the district; Kambui north forest reserve and Gola forest reserve in addition to stretch of protected forests.

Sampling technique, sample size and intensity

Random sampling method was used to select the respondents from the key producing villages. Purposive sampling based on probability proportionate to size was adopted in selecting respondents from each identified key stakeholder group. Therefore, for stakeholder groups whose total population exceeded 10 people, 30% of the populations were selected for sampling; while those whose total population was below ten, a 100% of the populations were sampled. Consequently, a total of 189 respondents from 10 key stakeholder groups operating in 7 key locations and communities; (Serabu, Deima, Wanjama, Guala, Wuima, Waima-Topkobu and Kenena city) were selected for sampling. The respective number of stakeholders sampled was 31 farmers, 12 chainsaw operator, 15 timber dealers, 16 transporters, 31 carpenters, 15 contractors, 9 pole producers, 19 fuelwood producers, 16 charcoal producers and 25 fuelwood sellers.

Data Collection

Empirical data for thisstudy were collected using structured questionnaire and interview schedule. The questionnaires contained questions to which respondents in each respective group were subjected to elicit information concerning their activities within the wood value chain. There were also feedback meetings to cross check information collected across stakeholders in the communities to ascertain the validity of the response.

Data analysis

The data were analyzed using descriptive statistics and presented in tables and graph.

Results and discussions

Demographic characteristics of respondents

Out of the 189 respondents sampled, those within the age group (26-35 yrs) represented the highest number of respondents (43.92%) in the study. Also, 73.54% of the respondentswere married, while 47.62% of them had noformal educationand 90.48% were male (Table 1).

These indicate that the greatest proportion of the key stakeholder in the wood value chain were married male youths and middle aged people with no formal education. This is in slight contrast with (Kokou and Nuto, 2009), who observed that most charcoal producers were women (52%) averaging 39years of age.

Table 1: Demographics of respondents

Age groups of respondents			
S/N	**Variables (Age group)**	**Frequency**	**Percentage**
1	18-25	13	6.88
2	26-35	83	43.92
3	36-45	56	29.63
4	46-55	19	10.05
5	≥56	18	9.52
	Total	**189**	**100.00**
Sex of respondents			
S/N	**Variables (Sex)**	**Frequency**	**Percentage**
1	Male	171	90.48
2	Female	18	9.52
	Total	**189**	**100.00**
Marital status of respondents			
S/N	**Variables (Marital Status)**	**Frequency**	**Percentage**
1	Single	40	21.16
2	Married	139	73.54
3	Separated	6	3.18
4	Divorced	4	2.12
	Total	**189**	**100.00**
Educational status of respondents			
S/N	**Variables (Educational Status)**	**Frequency**	**Percentage**
1	Primary	42	22.22
2	Secondary	54	28.57
3	Tertiary	3	1.59
4	Non-formal	90	47.62
	Total	**189**	**100.00**

Source: Field data, 2016

Key stakeholder groups within the value chain.

Farmers and carpenters constituted the highest percentage of respondents from stakeholder groups sampled. Each group, (farmers and carpenters) represented 16.40% of the key stakeholder groups sampled, while fuelwood seller represented the second highest stakeholders sampled, at 13.23%; followed by fuelwood producers at 10.05% (Table 2). With a high representation of farmers engaging in wood business; with faster rate of return on investment, there are threats of farming abandonment.

Table 2: Distribution of respondents per stakeholder group

S/N	Key stakeholders	Totals	Percentage (%)
1	Farmers	31	16.40
2	Chainsaw operators	12	6.34
3	Timber dealers	15	7.94
4	Transporters	16	8.47
5	Carpenters	31	16.40
6	Building Contractors	15	7.94
7	Pole producers	9	4.76
8	Fuelwood producers	19	10.05
9	Charcoal producers	16	8.47
10	Fuelwood sellers	25	13.23
Total		**189**	**100.00**

Source: Field data, 2016

Major tree species used for the production of wood products (sawn boards, poles, fuel wood and charcoal)

Results revealed thata total of 26 different tree species were inuse for the production of the different wood products across the production locations identified; furthermore, it was observed that some of tree species were targeted for the production of more than one type of wood product; especially for poles, fuelwood and charcoal. In summary, the numbers of different tree species commonly used in the production of wood products in Kenema were; 14 for sawn boards; out of which 8 (*Terminalia ivorensis, Ceiba pentandra, Terminalia superba, Lovoa trichilioides, Milicia regia, Antiaris africana, Funtumia africana* and *Albizia ferruginea* are more prevalently used), 5 for poles; out of which 2 (*Anisophyllea laurina and Piptadeniastrum africanum* are more prevalently used), 10 for fuel wood; out of which 2 (*Acioa scabrifolia* and *Funtumia africana* are more prevalently used) and 16 for charcoal; out of which 3 (*Macaranga* spp., *Funtumia* spp. and *Phyllanthus discoideus*are more prevalently used).

Activities carried out at the different stages of the value chain for each wood product

The following tables 3, 4, 5 and 6 contain information with respect to activities of key players and their activities within each stakeholder group and they reveal that their individual activities are as diverse as the number of individual groups. However,

there exist unique contributions made by members of each group in the value chain. The following tables explicitly describe activities at different stages of the value chain for each wood product by the different actors.

Key activities within sawn board value chain

The value chain of sawn boards starts in the forest where trees existing on farmlands are usually sold to chainsaw operators by farmers; regardless of girth size. The trees are felled, logged and converted into planks of various sizes/dimensions using power saws. Standard plank dimensions are 1"x12"x14' and 2"x12"x14' and 2" x 6" x 14'. The sawn boards are thereafter manually carried by the owner or hired labour to nearby roadsides in the village from where they are picked up by transporters and taken to timber dealers in the urban markets in Kenema city, Bo city or Freetown or directly to the final consumer.

Table 3: Activities carried out at the different stages of the value chain for sawn boards

Stage	Activities
Wood harvesting	This is the first activity in the value chain. It involves felling the tree by using chainsaw and/or axes by chainsaw operators.
Processing	At this stage, the felled tree is crosscut to market or customer specifications by chainsaw operators. The round logs are sawn into boards of different dimensions. The common size specifications are 1" x 12" x 14', 2" x 12" x 14' and 2" x 6" x 14'.
Transportation	Transportation is carried out at two stages of the value chain. Casual labourers are often hired to transport the sawn boards; usually on their heads to a landing area; which is typically the nearest roadside, for ease of subsequent vehicular transportation to the market by trucks hired by timber dealer.
Trading	Retailers buy from wholesellers and sells by dimension to carpenters and contractors.
Production	At this stage, the sawn boards bought from timber dealers or directly from chainsaw operators are transformed into finished products like beds, chair etc by carpenters.

Source: Field Survey, 2016

Key activities within poles, fuelwood and charcoal value chain

Poles are often derived from unmerchantable trees from forests or farm bushes; though in some cases, wood materials for firewood are also obtained from dead trees, while charcoals are also made from freshly felled merchantable trees and/or branches.They are acquired in similar manner as in the case of sawn boards; but felling is often done with the use of cutlasses. In some instances, landless farmers lease lands from land owners for farming purposes but first remove all trees on such lands and convert into different wood products for additional livelihood support.In some instances, landless farmers lease more land than they require form the land owners under the guise of utilizing all for farming, whereas, only a small portion of is eventually farmed, but all trees are felled and

converted to various products for sale. Harvested poles are sorted according to sizes and piled into small, medium and large sizes. Similarly, firewood; after being chopped into desired pieces and packed into bundles are stacked for the next stage in the process. Conversely, charcoals are produced by stacking chopped wood in dug earth pits and burned under controlled oxygen penetration until the desired product quality is achieved (a local Pyrolysis technology). The burned charcoal products are thereafter packed in 50 kg used rice bags in preparation for transportation.With these 3 wood products at these stages, they are then manually carried by therespective owners or hired labour to nearby roadsides in the villages they are produced. These wood products are often soldwholesale to transporters who in turn take them to dealers for resale in urban markets. These resellers therefore sell to end-users or sometimes, semi end-users. However, smaller quantities of the products are also taken to village centers and home using bicycles or motorbikes for retail in smaller quantities to local inhabitants. Charcoal producers from communities close to major highways going to Freetown also take smaller quantities of the product to road sides for direct sale to vehicle owners using the highways.

Table 4: Activities carried out at the different stages of the value chain for poles

Stages	Activities
Poles harvesting	This involves felling of young trees (usually unmerchantable trees of dbh around 10cm – 12cm and below) with cut losses by pole producers. Before harvesting, the pole producers usually give a gift in a form of money to the village chiefs or landowners in order to gain approval to negotiate for the transaction. A fee is also paid to the land owner in exchange for the trees to be felled.
Collection and Transport	During harvesting, the harvested poles are collected and transported to nearby roadside (landing) in the village ready to be transported to markets as in the case of sawn boards. The collection and transportation are either undertaken by the harvesters themselves or they may hire labourers. Poles are transported to the market by truck hired by pole dealers.
Trading	Large markets are often located at the urban centres and cities. Therefore bulk of trading in the commodity occurs there, after sorting the poles into small, medium and large sizes, based on their diameter class range.
Production	This product is mostly utilized by builders usually for scaffolding in housing construction.

Source: Field Survey, 2016

Table 5: Activities carried out at the different stages of the value chain for fuelwood

Stages	Activities
Harvesting	Harvesting of wood is usually part of the activities carried out during farming operations by farmers. It involves the felling of trees, cutting of dead wood and burning of the cleared farmland. The fuelwood producers

	or farmer use simple tools like cutlasses, axes etc. for wood harvesting. Engaging in fuelwood sale is an alternative livelihood activity for farmers and farming families.
Collection and stacking	This is the second activity in the fuelwood value chain. The collection of fuel wood can be done by the same person who harvests the wood. The wood harvesters or fuelwood producers may also hire labourers or help from family members for collection and stacking in preparation for transportation.
Transportation	Transportation is a major activity in wood products value chain and it ensures the movement of fuelwood from processing site to markets. Transportation is done in two stages. In the first stage, the harvested wood is taken to the roadside in the village and in the second stage; it is transported to the urban markets by hired truck by wood sellers or transporters.
Trading	Retailers buy fuel-wood from the wholesaler and repack the product in smaller quantities for sale in the different neighborhoods. Retailers resell at specialized fuelwood markets, common markets, at roadsides in local neighborhoods often for domestic users.
Consumption	Households are the main consumers of wood-fuel for cooking, followed by small scale industries such as bakeries, the agro-processing sector and the services sector which includes businesses such as restaurants, etc.

Source: Field Survey, 2016

Table 6: Activities carried out at the different stages of value chain for charcoal

Stages	Activities
Wood harvesting and collection	These are the first activities in the charcoal value chain. Harvesting involves cutting the trees, chopping to a required size, drying and packing into an earth oven.
Processing and production	Charcoal is produced from dead and dry wood, while production and processing is carried out in earth-mound ovens with just the right amount of heat which is skillfully regulated through indigenous pyrolysis technology by the producer. The burning process takes 3 to5 days before the product is removed from the oven; although only about 20% of wood placed in the oven results in saleable charcoal due to non-standardization of the wood sizes used and pyrolysis process; according to the producers. The burnt charcoal is allowed to cold and ready for packaging in 50kg bags ready for market.
Transportation	Bagged charcoal is transport by labourers or the charcoal producers themselves from production site to roadside for marketing. Transport varies from head-loading, bicycles and motorcycles; to cars, pick-up trucks, lorries and large trucks. Mode of transport depends on the quantity of product, distances that have to be covered and the financial means of the traders.

Trading	Charcoal retailers buy the product from the wholesaler and repack the goods in smaller quantities for resale in the different neighborhoods. They resell at specialized markets, common markets at roadsides in local neighborhoods. In many instances, producers from villages close to major highways also take their bags of charcoal to the highway roadsides for direct sale to travelers on their ways to big cities like Bo and Freetown.
Consumption	Households are the main consumers of charcoal for domestic cooking and clothe ironing. It is also used by small scale industries, bakeries, restaurants etc.

Source: Field Survey, 2016

Wood extraction from forest

Sawn boards on display in market

Poles on display in market

Fuelwood at landing area

Fuelwood displayed on highway

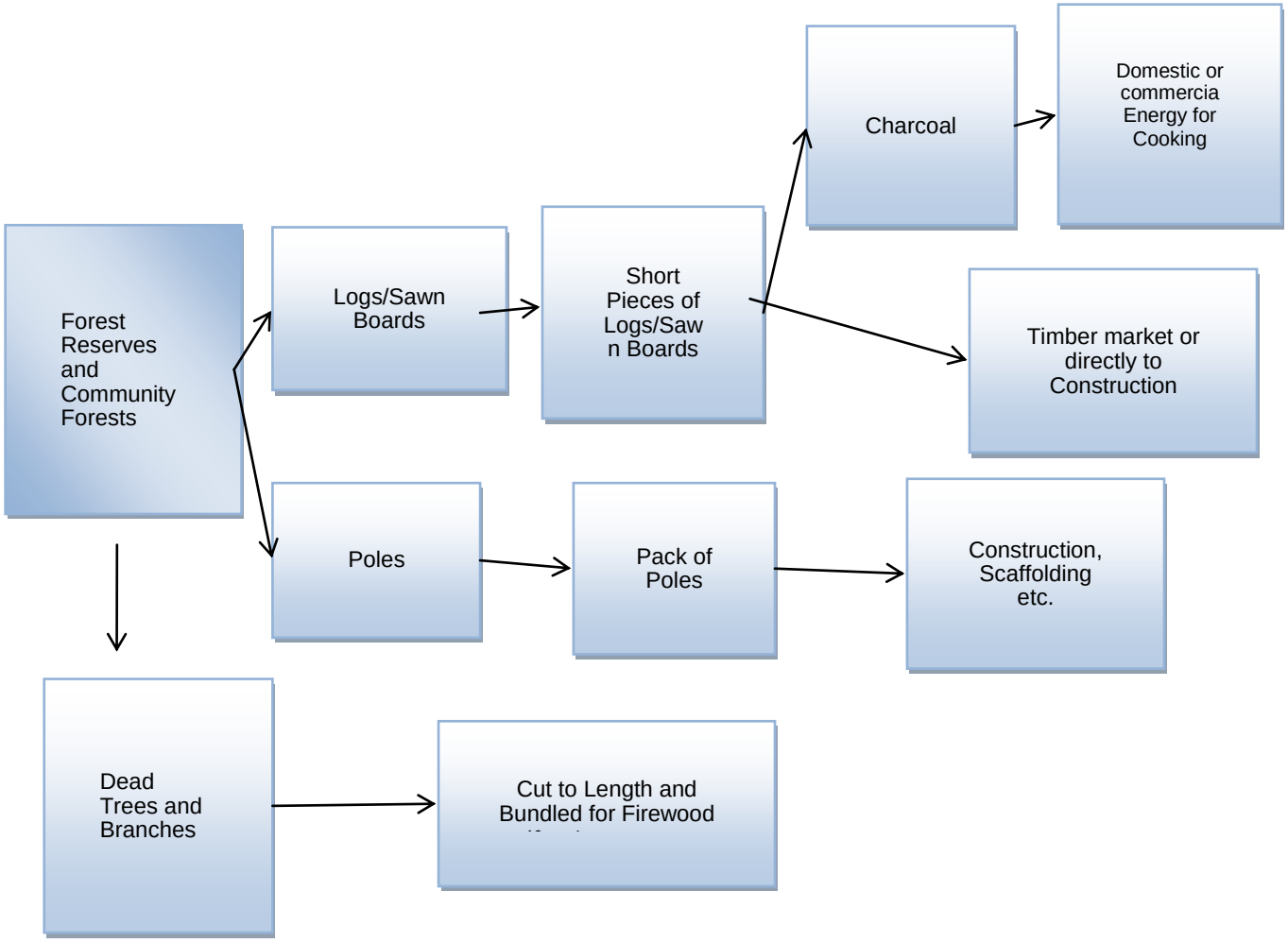
Bags of charcoal for sale

Fig. 1: Typical pictures of wood products in Kenama

Value chain of forest wood products in Kenema

Figure 2 below illustrates a typical value chain for forest wood products in Kenema. It shows wood product flows from primary commodity to final products such as Sawn boards, poles, fuelwood and charcoal; after which they move to final consumer who either use them directly or process into other value added products as in the case of sawn boards. The Schematic value chain mapping below; is a more or less simplified version of the rather complex "actual" value chain. While it might be assumed that a product value chain progresses in a simple linear sequence, this was observed not to be the case for wood products value chain in Kenema. In reality, because the chain is predominantly informal, there are instances whereby wood products have to pass through many other intermediaries between the producers and end-users; thereby creating clumsy links within the chain. Also, this study revealed that the wood value chain in Kenema is generally demand driven and with the exception of sawn boards and

poles, wood quality is not given serious consideration prior to production.



Source: Field data, 2016

Fig. 2: Simplified informal value chain of forest wood products in Kenema

Average production and marketing costs and profits accruable from wood products trade in Kenema

Table 7 shows the different fees and costs in one year associated with an 'average' board production and marketing operating in Kenema district; based on the assumption that the traders order 500 boards each month, amounting to 6,000 sawn boards each year. Although council and government cost/fees are exact, all other costs and prices are average, including selling price representing both hard and soft woods in 1" x 12" x 14' dimensions.Therefore, the estimates are meant as a guide of prevailing general dynamics within the district at the time of the study and may vary based on individual specific circumstances.

Table 7: Average production costs and profits accruable from sawn board trade

	Item	Price (Le)	Type	Quantity	Annual Total (Le)	Annual Total *($)
	Chainsaw operator	4,000	per board	6000	24,000,000	3,200

Costs	Fuel used	3,750	per liter	7200	27,000,000	3,600
	Chiefdom head	250,000	per year	1	250,000	33.33
	Forestry	1,000	per board	6000	6,000,000	800
	Council	250,000	per month	12	3,000,000	400
	Timber sellers Association (ACOTIDA) fee	50,000	per trip	12	600,000	80
	Government License	6,000,000	per year	1	6,000,000	800
	Transportation cost	3,000	per board	6000	18,000,000	2,400
	Land owners	10,000	per board	2400	24,000,000	3,200
	Total				**108,850,000**	**14,513.33**
Selling price	Boards	30,000	Per board	6000	180,000,000	24,000
ANNUAL PROFITS					**71,150,000**	**9,486.66**

*Exchange rate = Le 7500 / 1$

Average production costs and profits accruable from pole trade

Table 8 below presents an illustration of the various fees and costs for an 'average' pole sellers operation in one year. The table is based on the assumption that the seller orders 160 dozen poles each month (1, 920 dozens each year), and buys, transports and sells at the average amounts noted in this table. There is great diversity in the size and operation of the different sellers and thus the calculation below is not meant as an exact depiction but rather as an indication of the 'average' pole marketing.

Table 8 - Average production costs and profits accruable from pole trade

	Item	**Price (Le)**	**Type**	**Quantity**	**Annual Total (Le)**	**Annual Total *($)**
Costs	Cost of poles at source village	6,000	per dozen	1920	11,520,000	1,536
	Transport cost	6,000	per dozen	1920	11,520,000	1,536
	Forestry	50,000	per year	12	600,000	80
	Council	150,000	per year	1	150,000	20
	Ground fee	120,000	per trip	24	2,880,000	384

	Land owner	20,000	per trip	24	480,000	64
	Totals				**27,150,000**	**3,620**
Revenue	Poles	27,000	per dozen	1920	51,840,000	6,912
ANNUAL PROFITS					**24,690,000**	**3,292**

*Exchange rate = Le 7500 / 1$

Average production costs and profits accruable from fuelwood trade

Table 9 shows the different fees and costs in one year, associated with an average fuelwood production and marketing operation in Kenema district. Based on the assumption that the trader orders 800 bundles each month (9,600 bundles per year), and that they buy, transport and sell at the average costs shown in the table. There is great difference in the size and operation of the different fuelwood sellers, and thus the calculation below is not meant to be an exact depiction for all sellers, but rather an illustration based on the available data of the fuelwood trade in the district.

Table 9: Average production costs and profits accruable from firewood trade

	Item	Price (Le)	Type	Quantity	Annual Total (Le)	Annual Total *($)
Costs	Cost of firewood at source village	2,000	per bundle	9600	19,200,000	2,560.00
	Transport cost	300,000	per trip	24	7,200,000	960.00
	Forestry	50,000	per trip	24	1,200,000	160.00
	Council	130,000	per year	1	130,000	17.33
	Ground fee	170,000	per month	12	2,040,000	272.00
	Land owner	100,000	per year	1	100,000	13.33
	Totals				**29,870,000**	**3,982.66**
Revenue	Fuelwood	4,000	per bundle	9600	38,400,000	5,120.00
ANNUAL PROFITS					**8,530,000**	**1,137.33**

*Exchange rate = Le 7500 / 1$

Average production costs and profits accruable from charcoal trade

Table 10 below presents the different fees and costs associated with the annual operations of an average charcoal marketer operating in Kenema district. Based on the assumption that the charcoal seller buys an average amount of 300 bags of charcoal every month (3,600 per year) of 50kg size and he/she buys transports and sells at the average price shown in Table 3.

Table 10: Average production costs and profits accruable from charcoal trade

	Item	Price (Le)	Type	Quantity	Annual Total (Le)	Annual Total ($)
Costs	Cost of charcoal at source village	7,000	per bag	3600	25,200,000	3,360.00
	Transport cost	1,000	per bag	3600	3,600,000	480
	Forestry	1,000	per bag	3600	3,600,000	480
	Council	110,000	per year	1	110,000	14.66
	Ground fee	1,000	per bag	3600	3,600,000	480
	Farmers fee	100,000	per year	1	100,000	13.33
	Totals				**36,210,000**	**4,828.00**
Revenue	Charcoal	12,000	per bag	3600	43,200,000	5,760.00
Annual profits					**6,990,000**	**932.00**

*Exchange rate = Le 7500 / 1$

Annual profits accruable each wood product

The annual profits made by people that are involved in the production and marketing of sawn wood, construction poles, firewood and charcoal is presented in fig. 3.

Fig. 3: Aannual profits accruable from each wood product

Conclusions and recommendation

Firstly, this value chain study revealed that with growing population, demand for wood products is sure to increase; therefore, in the face of high demand and fast rate of return on investment, this sub-

sector will attract the attention of more entrants especially rural farmers (most of whom are at present, youths and middle aged people with no formal education) and this may potentially lead to farming abandonment. Therefore, society (government and non-governmental stakeholders) must be proactive by creating awareness on dangers inherent in unsustainable logging, inefficient wood processing practices and consequences of food insecurity and by facilitating climate smart initiatives to reverse exposure and promote rural economic growth.

Secondly, many land owners are ignorant of tree tenure and value; therefore, educating them will help them for making good judgment on land lease arrangements.

Finally, complexity of the wood value chain and inefficient production/ processing results in significantly low profit margins; with direcon sequences to the forest and increases climate change vulnerability as producer may respond by increasing production to reduce losses. Therefore, there is urgent need for interventions aimed at helping rural people take advantage of weak points in the value chain to create wealth while maintaining environmental integrity.

References

Amanor, K. (2012). Seeing the Trees from the Biocultural Diversity: Forestry Management, Smallholder Agriculture, and Environmental Politics in Ghana, "In: "Why Do We Value Diversity? Biocultural Diversity in a Global Context ," edited by Gary Martin, Diana Mincyte, and Ursula Münster, RCC Perspectives 2012, no. 9, 73–77.

ESDA. (2005). National Charcoal Survey: Exploring the potential for a sustainablecharcoalindustry. ESDA, Kenya.

FAO (2009). Forest Products Annual Market Review 2008-2009. United Nations, New York and Geneva.

GoSL, (2010): Sierra Leone Forest Policy.

GTZ (2007): ValueLinks Manual: The Methodology of Value Chain Promotion, FirstEdition.GTZ, Eschborn, Germany.

Haartveit, E. Y., Kozak, R. A., & Maness, T. C. (2004): Supply chain management mapping for the forest products industry: Three cases from western Canada. Journal of Forest Products Business Research, *1*.de

Janvry, A. and Sadoulet, E. (2010). Agricultural Growth and Poverty Reduction: Additional Evidence. The World Bank Research Observer, 25 (1).

Kaplinsky, R. and Morris, M. (2001): 'A Handbook for Value Chain Research', prepared for the IDRC, Institute of Development Studies: Sussex.

Kituyi, E. (2001). Towards Sustainable Charcoal Production and Use: a SystemsApproach. African Centre for Technology Studies, Nairobi, Kenya.

Kokou, K and Nuto, Y. (2009). Assessment of Charcoal Production and Impact of Environmental Policies in Limited Forest Resources Countries: The case of Togo, West Africa Article in Discovery and innovation 21(1-2) · November 2009 DOI: 10.4314/dai.v21i1-2.48173.

Melin, M and Puentes, Y. (2016). Introduction to Value Chain Analysis; A training manual under the 'Building Biocarbon and Rural Development in West Africa' project, 11.5.2016 Njala University, Sierra Leone.

Mugo, F. and Ong, C. (2006). Lessons of eastern Africa's unsustainable charcoal

trade. ICRAF Working Paper no. 20. Nairobi, Kenya. World Agroforestry Centre.

Sepp, S. and Mann (2009). Analysis of charcoal value chain – general considerations. GTZ Germany.

Statistic Sierra Leone (2015): Population and housing census.

Appendix

Major Tree Species Used For the Production of Wood Products (Sawn Boards, Poles, Fuel Wood and Charcoal)

Location	Wood products			
Serabu	**Sawn boards**	**Poles**	**Fuel wood**	**Charcoal**
	1.*Terminalia ivorensis* 2. *Ceiba pentandra* 3.*Terminalia surpaba* 4.*Khaya anthotheca* 5.*Lovoa trichilioides* 6.*Milicia regia* 7.*Antiaris Africana*	1.*Piptadeniastrum africanum* 2.*Xylopia aethiopica* 3.*Anisophyllea laurina*	1.*Pentaclethra microphylla* 2. *Funtumia 16fricana* 3. *Diospyros* spp. 4. *Acioa scabrifolia* 5. *Maracanga* spp.	1. *Daniellia thurifera* 2. *Smeathmanmia* spp. 3. *Fiscus* spp. 4. *Macaranga* spp.
Deima	1.*Terminalia ivorensis* 2. *Terminalia surpaba* 3. *Milicia regia* 4. *Ceiba pentandra* 5. *Fiscus* spp. 6. *Heritiera utilis* 7. *Entandrophragma utile* 8. *Funtumia 16fricana* 9. *Uapaca guineensis* 10. *Daniellia thurifera*	1. *Xylopia aethiopica* 2.*Piptadeniastrum africanum* 3.*Acioa Scabrifolia*	1.*Pentaclethra microphylla* 2.*Dichrostachys glomerata* 3. *Smeathmanmia* spp. 4. *Funtumia africana*	1.*Pentaclethra microphylla* 2.*Uapaca guineensis* 3. *Funtumia africana*
Wanjama	1. *Ceiba pentandra* 2.*Terminalia ivorensis* 3. *Terminalia surpaba* 4. *Milicia regia* 5. *Albizia ferruginea* 6. *Danielliia thurifera*	1. *Diospyros* spp. 2. *Xylopia aethiopica* 3.*Piptadeniastrum africanum*	1. *Phyllanthus discoides* 2. *Acioa scabrifolia* 3. *Smeathmanmia* spp. 4. *Fagara* spp.	1. *Acioa scabrifolia* 2. *Phyllanthus discoides* 3. *Ochthocosmus 16fricana* 4. *Fagara* spp.

Guala	1.*Ceiba pentandra* 2.*Terminalia ivorensis* 3. *Terminalia surpaba* 4. *Milicia regia* 5. *Albizia ferruginea* 6. *Antiaris 17fricana* 7. *Heritiera utilis* 8. *Funtumia 17fricana* 9. *Entandrophragma utile* 10. *Lovoa trichilioide*	1. *Piptadeniastrum africanam* 2.*Xylopia aethiopica* 3. *Anisophyllea laurina*	1. *Phyllanthus discoides* 2.*Pentaclethra microphylla* 3. *Funtumia 17fricana* 4. *Acioa scabrifolia* 5. *Macaranga* spp.	1. *Smeathmanmia* spp. 2. *Danielliia thurifera* 3. *Macaranga* spp. 4. *Fiscus* spp. 5. *Anisophyllea laurina*
Wuima				
	1. *Ceiba pentandra* 2. *Terminalia ivorensis* 3. *Terminalia surpaba* 4. *Milicia regia* 5. *Heritiera utilis* 6. *Antiaris 17fricana* 7. *Albizia ferruginea* 8. *Funtumia 17fricana* 9. *Lovoa trichilioides*	1.*Piptadeniastrum africanam* 1. *Xylopia aethiopica*	1. *Phyllanthus discoides* 2. *Ochthocosmus 17fricana* 3.*Dichrostachys glomerata* 4. *Funtumia 17fricana*	1.*Dichrostachys glomerata* 2. *Funtumia 17fricana* 3. *Fagara* spp. 4. *Smeathmanmia* spp. 5. *Phyllanthus discoides* 6. *Macaranga* spp.

Waima Tokpobu	1. *Ceibapentandra* 2.*Terminalia ivorensis* 3. *Terminalia surpaba* 4.*Milicia regia* 5.*Heritiera utilis* 6. *Antiaris africana* 7. *Albizia ferruginea* 8. *Funtumia* spp. 9. *Lovoa trichilioides* 10. *Danielia thurifera* 11. *Uapaca guineensis* 12. *Albizia* spp. 13.*Mitragyna stipulosa*	1. *Anisophyllea laurina* 2.*Piptadeniastrum africanum* 3. *Xylopia aethiopica*	1.*Phyllanthus discoides* 2.*Ochthocosmus africana* 3.*Dichrostachys glomerata* 4. *Funtumia africana* 5. *Fagara* spp. 6. *Diospyros* spp. 7. *Acioa scabrifolia*	1. *Phyllanthus discoides* 2. *Macaranga* spp 3. *Diospyros* spp. 4. *Funtumia* spp. 5. *Acioa scabrifolia* 6.*Pentaclethra microphylla*

Carbon sequestration in forest ecosystem and methods for its evaluation

Vishwajeet Sharma, Harish Chand, Nikita Rai and Mukesh Prasad
Forest Research Institute
Indian Council of Forestry Research and Education, Ministry of Environment, Forest and Climate Change
Dehradun
E-mail: svishwa37@gmail.com

Introduction

Carbon sequestration is the process of removing additional carbon from the atmosphere and deposition it in other reservoir principally through changes in land use (Mandal et al., 2005). Forestry, agro forestry and improved agronomic practices are major options for carbon sequestration, which in terrestrial ecosystem is defined as absorption of atmospheric carbon dioxide by photosynthesis or technology based sequestration activities such as deep sea based storage of liquefied carbon dioxide (Bass et al., 2000). In the terrestrial system carbon is sequestrated in rocks and sediments, in swamps, wetlands and forests, and in the soils of forests, grasslands and agriculture.

Carbon sequestration in terrestrial ecosystems can also be defined as the net removal of CO_2 from the atmosphere into long-lived pools of carbon. The pools can be living, above ground biomass (e.g., trees), products with a long useful life created from biomass (e.g., lumber), living biomass in soils (e.g., roots and micro organisms), or recalcitrant organic and inorganic carbon in soils and deeper subsurface environments. It is important to emphasize that increasing photosynthetic carbon fixation alone is not enough. This carbon must be fixed into long-lived pools. Otherwise, one may be simply altering the size of fluxes in the carbon cycle, not increasing carbon sequestration.

Forests play an important role in the global carbon cycle. They not only have a significant impact on climate change, but also influence it. Through their destruction, forests can be serious sources of greenhouse gases and through their sustainable management they can be important sinks of the same gases. It has been proved that the land where the stock is highest, had the highest stock of soil organic carbon in comparison to other land use system (Singh, 2005). Several studies have indicated that the global potential for enhancing carbon storage in forest and agricultural ecosystems may be as much as 60-90 pentagrams of carbon (De Jong et al., 1999).

Forest ecosystems can be sources and sinks of carbon (Watson et al., 2000). The carbon reservoir in the world's forests is higher than the one in atmosphere. While forests in most temperate regions are net carbon sinks, tropical forests accounts for about one third of global carbon emissions (IPCC, 2001). Deforestation and burning of forests releases CO_2 to the atmosphere. Indeed, land use change and forestry are responsible for about 25% of all green house gas emissions. Forest ecosystems can, however, also help reduce greenhouse gas concentrations by absorbing carbon from the atmosphere through the process of photosynthesis. The forests have the

greatest potential to sequester carbon primarily through reforestation, agro forestry and conservation of existing forests (Brown et al. 1996). The global terrestrial carbon stock is shown in the Fig. 1.

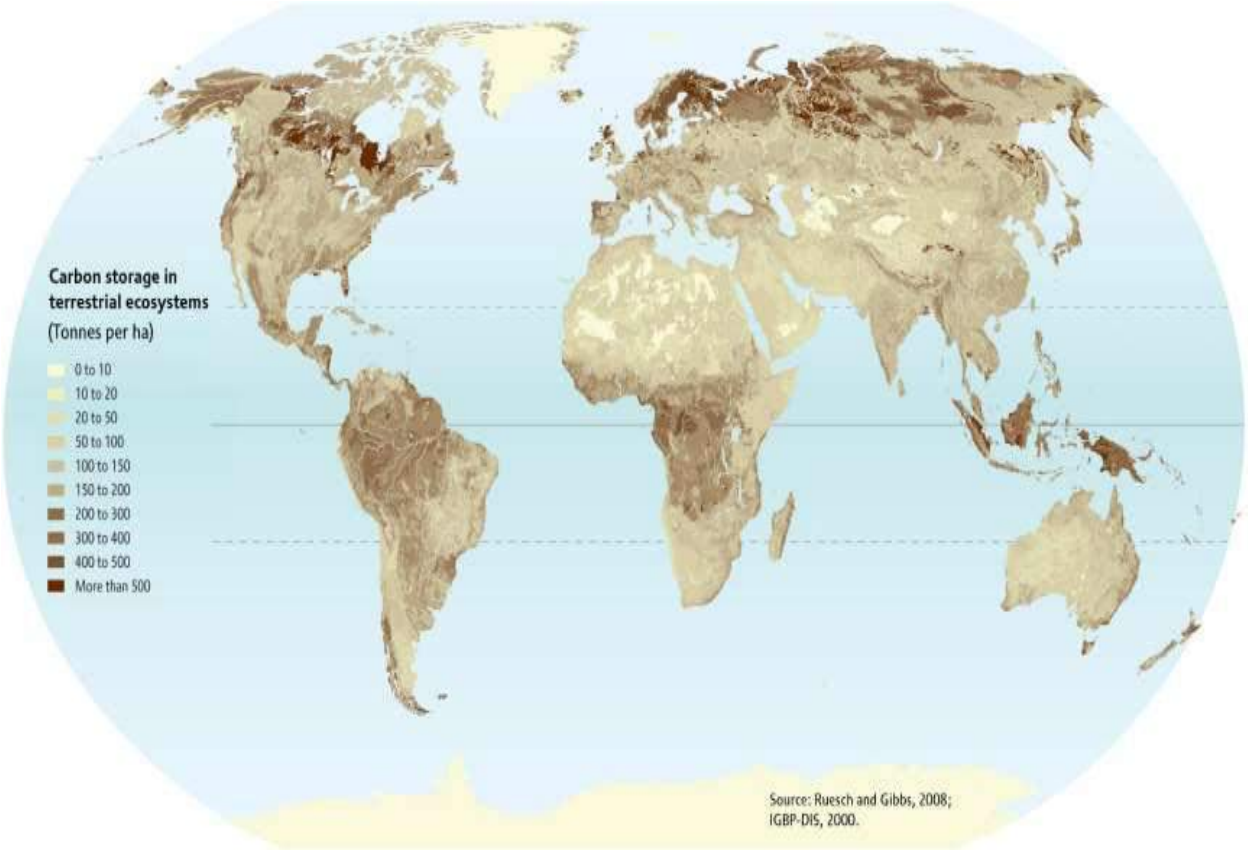


Fig. 1. Global terrestial carbon stock (Source: Ruesch and Gibbs, 2008)

Forest ecosystems store more than 80% of all terrestrial above-ground carbon and more than 70% of all soil organic carbon (Six et al., 2002). The role of tropical forest in global biogeochemical cycle especially the carbon cycle and its relation to green house gas effect has heightened interest in estimating the biomass density of tropical forest. The quantity of biomass in a forest determines the potential amount of carbon that can be added to the atmosphere or sequestrated on the land when forests are managed for meeting emission targets. The quantification of biomass is required as the primary inventory data to understand carbon pool changes and productivity of forests.

Method of measuring carbon sequestration in forest ecosystem

Sampling technique

Systematic sampling with sampling intensity of 0.01% is applied. Circular plot each of 250 m^2 area is taken for sample plot measurement as in figure 2. Circular plots of 8.92 meter radius are used for sampling trees of diameter more than 5 cm at breast height. Another nested plot of 5.64 m radius inside the big circle is made to measure plants of DBH (1-5) cm. Similarly, another nested plot of 1 m radius at the center is made to count regenerations of diameter less than 1 cm at breast height. Finally, at the center, a circle of 0.56 m radius is made for the measurement of leaf litter, herbs and

shrubs. The height and circumference of dead stumps within the circular plot of 8.92 m is also measured to find out dead carbon in ton/ha.

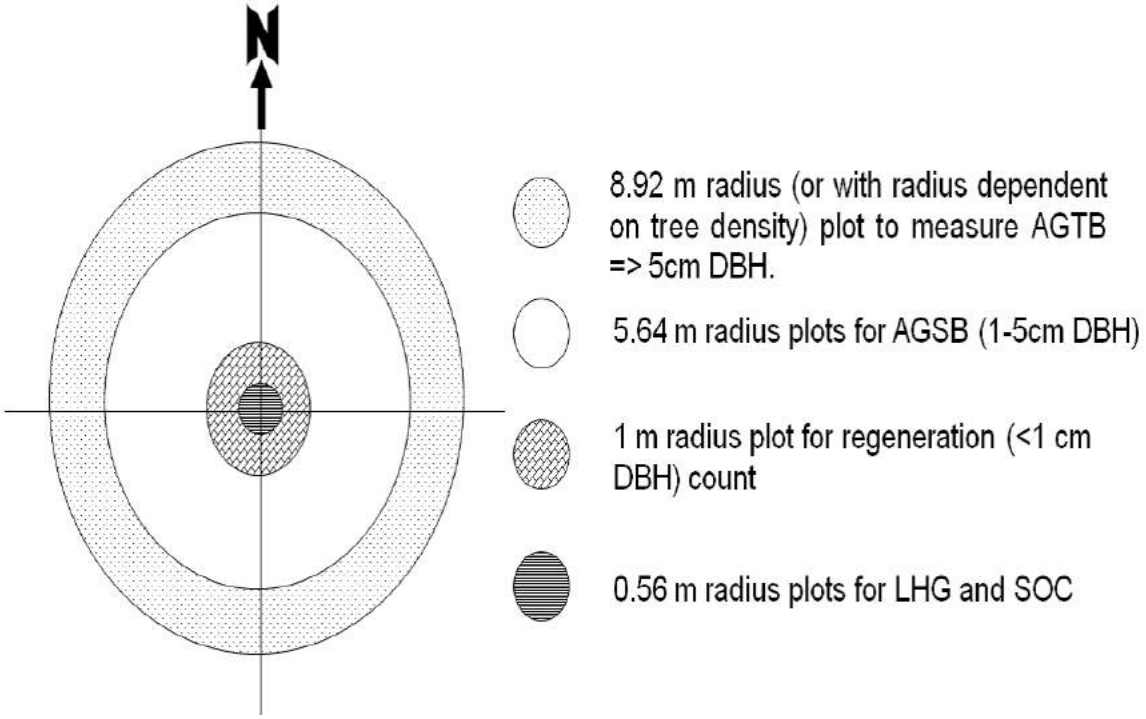


Fig. 2. Sample plot layout (Source: ANSAB, 2010)

Carbon estimation

Estimation of total carbon present in the forest ecosystem is required to find the total carbon sequestration in forest ecosystem. The measurement includes:

- Common methods (Biomass expansion factor)
- Allometric regression equation (Forest type and species specific)
- The major carbon pools of the forest ecosystem are:
- Above Ground Biomass (Stem wood, branch wood, bark, foliage, seeds etc)
- Below Ground Biomass (Coarse root, fine root & stumps)
- Deadwood (Coarse and fine)
- Soil Organic Matter &
- Leaf Litter, Grass and Herb

Method of measuring each pools of carbon is given below:

Above ground biomass (AGB)

- Bole mass = Volume * Wood density
- Above Ground Biomass = Bole mass * Biomass expansion factor
- Total carbon (T1) = AGB * 0.47

Below ground biomass (BGB)

- Below Ground Biomass = AGB * 0.26
- Total carbon (T2) = BGB * 0.47

Deadwood (Organic matter)

- Deadwood biomass = (AGB + BGB) * 0.11
- Total carbon (T3) = Deadwood biomass * 0.47

Soil organic matter (SOM)

The Walkey-Black method (Jackson, 1958) will be applied to measure the soil organic carbon percent. Total soil organic carbon will be calculated using the

formula given below (Chabbra et al., 2002):

SOC= Organic carbon content%*soil bulk density (kg/m^3)*thickness of horizon (cm)

Further, it was expressed in ton/ha.

Bulk density

Metal core ring sampler of dimension, 9.7 cm length and 3.86 cm diameter will be used for determining the bulk density of the soil samples along the soil profile. The fresh soil extracted by metal core ring sampler will be bagged in plastic bag, sealed, leveled and transported to the laboratory for the determination of oven dry weight and the Bulk density will be computed using the following relations:

Bulk density (gm/cm3) = (oven dry weight of the soil)/ (volume of the core)

T4= Soil Organic Matter Carbon

Leaf litter, grass and herb (LGH)

All under storey bushes, grasses and herbaceous layers will be clipped and weighed. Clipped samples will be dried inside oven at temperature of 102 degree centigrade for 24 hours. The following formula will be applied to calculate the biomass value of leaf, litter, twigs, grass and herbs (Lasco et al., 2005).

$$ODW = \frac{TFW - (TFW \times (SFW - SODW))}{SFW}$$

where,

ODW = Total oven dry weight

TFW = Total fresh weight

SFW = Sample fresh weight

SODW = Sample oven dry weight

The carbon content in LHG, was calculated by multiplying LHG with the IPCC (2006) default carbon fraction of 0.47.

T5= ODW (t) * 0.47

Total carbon content in all pools (T) = T1 + T2 + T3 +T4 + T5

Total carbon sequestration in forest ecosystem = Total carbon * 3.6663

Remote sensing involved in measurement of carbon

Modern technology includes measurement of forest carbon sequestration by application of remote sensing. Carbon stock measurement is based on vegetation cover derived from remote sensing (Scanning laser i.e. LIDAR data). The vegetation cover is then converted to carbon by multiplying with biomass-carbon conversion factor.

- Total wood volume = Vegetation cover * 1.454 * 0.396 (m^3)
- Total dry matter biomass = Wood volume * 0.43 (tonnes)
- Total carbon = Dry matter biomass * 0.5 (tonnes)
- Total carbon dioxide sequestrated = Total carbon * 3.6663 (tonnes)

Discussion and conclusion

Forest ecosystem is the major biological scrubber of atmospheric CO_2. Its careful management can significantly increase it efficiency. Managed forests are hence most effective and reliable sinks of GHGs sequestering more carbon than unmanaged forests (Levy et al. 2004). Among different sustainable forest management practice existing in the world, community managed forestry program is preferable option of carbon sequestration, primarily in developing countries (Klooster and Masera 2000**).** Community forestry programme is increasing carbon stock in biomass as well as in soil through two mechanisms. Primarily, there is significant increase in carbon pool due to active reforestation and afforestation in barren land secondly decreased emission due to control of deforestation. Carbon sequestration in forest soils has a potential to decrease the

rate of enrichment of atmospheric concentration of CO_2. Increase in carbon stock of forest soils can be achieved through forest management including site preparation, fire management, afforestation, species management, selection and use of fertilizers.

The temporal carbon dynamics are characterized by long periods of gradual build-up of biomass (sink), alternated with short periods of massive biomass loss (source). Forests thus switch between being a source or a sink for carbon. It is believed that the goal of reducing carbon sources and increasing the carbon sink can be achieved efficiently by protecting and conserving the carbon pools in existing forests (Brown et al. 1996).

The productivity of any forest depends on the age of its vegetation. It is well established that forest plantations sequester carbon till maturity which would vary from 25 to 75 years depending upon the type of forests. At later stages, there is only marginal carbon sequestration. In natural forests, there is a net addition to standing biomass leading to carbon storages only until maturity. In mature forests all of the gross primary productivity is either used up in respiration or returned to soil as litter with no net addition to the standing biomass. These mature forests do not significantly contribute towards carbon uptake, through important for regeneration and thus in sustaining biodiversity (Lal, 2004).

Forest management in the world effectively enhances biomass carbon, and CFM may be a good contributor to $REDD^+$ programmes in the future. Soil carbon forms a large portion of the overall carbon content of many forest ecosystems, and if the forest is cleared, it may be lost, at least in part. The amount of biomass sequestered in forests under CFM depends on the forest management practices and users awareness level. Management of forests was evolved after the late 1970's when massive deforestation happened in state controlled forests. After the understanding of people's dependent in forest products in their livelihood and their vital role in the conservation of forest, the concept of utilization of these resources sustainably arose within the management. Silviculture practice, which is done periodically and regularly, is the part of management process, by which they not only fulfill local people's daily requirement but also maintain forest stability. The various studies shows that sustainable management of forest by people has lead to increase in carbon stock as well as in carbon sequestration. This shows potentiality of the carbon sink in the forests. Carbon dioxide is simply sequestrated by the plant through photosynthesis which is stored as plant biomass.

Trees can develop a large biomass and capture a large amount of carbon over a growth cycle of many decades. So, forest can capture a large volume of carbon for a long period of time. So, carbon sink and storage in the forest are important factors to mitigate climate change. Communities are to engage in this sort of forest management to promote the protection of forests avoiding the deforestation (Skutsch, 2006). Obviously, contributions of community forest can help to meet the binding target of emission reduction of Kyoto Protocol (Gundimeda, 2004). Conclusively; the forest management has a global role in reversing the process of deforestation and sequestrating carbon and

a local function of promoting rural development activities.

References

ANSAB (2010). Forest Carbon Stock Measurement Guidelines for measuring carbon stocks in community-managed forests.pp.-1-79.

Bass, S., Dubios, O., Mauro Costa, P., Pinard, M., Tipper, R., and Wilson, C. (2000). Rural livelihoods and carbon management. IIED natural resource issued paper.

Brown, S., Sathaye, J., Cannell, M., Kauppi, P.E. (1996). Management of forests for mitigation of greenhouse gas emissions. In: Watson, R.T., Zinyowera, M.C., Moss, R.H. (Eds.), Climate Change (1995). Impacts, Adaptations and Mitigation of Climate Change, Scientific Analyses. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, pp 773–798.

Chhabra, A., Palria, S., Dadhwal, V.K. (2002). Growing stock based forest biomass estimate for India. Biomass and Bioenergy 22, 187–194.

De Jong, B.H.J., Montoya - Gomez, G. (1999). An economic analysis of potential for carbon sequestration by forest: evidences from southern Mexico. Ecological economics, 33: 313-327.

Gundimedia, H. (2004). How 'sustainable' is the 'sustainable development objective' of CDM in developing countries like India? Forest Policy and Economics 6(3-4), 329-343.

IPCC. (2001). Mitigation, contribution of working group III to the third assessment report of the Intergovernmental Panel on Climate Change. Cambridge (UK): The Press Syndicate of the University of Cambridge.

Klooster, D. and Masera, O. (2000). Community forest management in Mexico: carbon mitigationand biodiversity conservation through rural development. Global Environmental Change, 10, 259-272.

Lal, R. (2004). Soil carbon sequestration to mitigate climate change. Carbon Management and Sequestration Center, School of Natural Resources, The Ohio State University, OARDC/FAES, 2021 Coffey Road, Columbus, OH 43210, USA.

Lasco, R. D., Pukhil, F. B., CRUZ R. V. O., Pulhin, J. M., Roy, S. S. N. (2005). Carbon budgets of terrestrial ecosystems in the Pantabangan-Carranglan Watershed. AIACC Working Paper No. 10. A joint project of START, the Third World Academy of Sciences, and the UN Environment Programme, 23 pp.

Levy, P. E., Cannel, M. G. & Friend, A. D. (2004). Modeling the impact of future changes in climate, carbon dioxide concentration and land use on natural ecosystems and the terrestrial carbon sink. Global Environmental Change, 14, 21-30.

Mandal, R.A., Laake, P. Van. (2005). Carbon sequestration in community forests:an eligible issue for CDM (A case study of Nainital, India).Banko Janakari,15(2),64-72.

Ruesch, A., Gibbs, H.K. (2008). New IPCC Tier-1 global biomass carbon map for the year 2000. Carbon Dioxide Information Analysis Center (CDIAC), Oak Ridge National Laboratory, Oak Ridge, Tennessee. Available online at: http://cdiac.ornl.gov/epubs/ndp/global_carbon/carbon_documentation.html.

Singh, P.B. (2005). Carbon Sequestration in community forest system: A case study

from Kusunde Community Forest, Bharat Pokahari, VDC in Kaski District. A research thesis for B. Sc. Thesis, Tribhuwan University, Institute of forestry, Pokhara, Nepal.

Six, J., Conant R.T., Paul, E.A., & Paustain, K. (2002). Stabilization mechanisms of soil organic matter. Implications for C-saturation of soils: Plant soil, 241:15-176.

Skutsch, M. (2006). The rationale for carbon crediting for community forest management. In Skutsch (Ed.) Can Carbon Income Combat Forest Degradation, Rational and Case Studies. Technology and Sustainable Development, University of Twente, the Netherlands.

Watson, R.T., Noble, J.R., Bolin, B., Ravindranath, N.H., Verardo, D.J. and Dokken. (2000). Land use, land use change and forestry. IPCC, Special report. Cambridge University Press, UK 575 pp.

Lannea coromandelica – A potential multipurpose tree for industrial agroforestry

R. Deepak Kumar

College of Forestry, Kerala Agricultural University
Vellannikara-680 656
E-mail: deepakkumarforestry@gmail.com

Introduction

Present-day traditional agriculture is facing several challenges such as technological, resources and capital constraints. To overcome these challenges tree based farming (agroforestry) is one of the viable options with judicious integration of forest trees with agricultural crops and livestock. It is also one of the main alternative sources for food, fuel, raw materials to the industries and other forest products in present-day India (NRCAF, 2013). Hence, it helps to improve the sustainable livelihood of famer and alleviation of poverty. India has a long tradition of cultivating various agricultural and horticultural crops such as tea, coffee, rubber, coconut, ginger, cardamom, areca nut and cardamom along with tree crops on their farm lands. However, trees crops should have characteristics like rapid growth, efficient dry matter production in terms of water and nutrient inputs, crown characteristics to maximize interception of solar radiation and ease of regeneration for the better suitability. In these circumstances, *Lannea coromandelica* (Houtt.) Merr. is one of the indigenous tree with several untapped potentials.

Botanical description

Lannea coromandelica (Houtt.) Merr. is a fast growing large size deciduous tree belongs to the family Anacardiaceae which is commonly known as Indian ash tree or Moi tree or wodier (English), Jhingini (Sanskrit), Oti (Tamil), Otiyan (Malayalam). It is naturally occurs in deciduous and dry evergreen forests of tropical Asia (Kaur et al., 2013). It grows upto 24 m in height and 1.5-1.8m in girth. The leaves are arranged in alternate, imparipinnate and densely reddish velvet while young. Clustered at end of the branches, leaflets are opposite, oblong, ovate, oblique base, acuminate apex, entire margin, 5-12 x 3-8cm lamina. Bark is rough, fibrous in nature, grey to dark brown in colour, exfoliating in small irregular flakes and crimson red or deep pink coloured blaze. Flowers are small, unisexual, yellowish green, the male in compound and female in simple racemes. Fruit are ovoid in shape, drupe, reddish colour and 1.2 cm long. Reniform shaped seed compressed in panicles at the end of leafless branches.

Cultivation practices

Seed collection and processing

The matured reddish colouredfruits were collected during the month of May – June from the ground and also from tree. It will lose their viability 25-35 days, it's immediately cleaned and dried under the shade. It has 6000 -10000 of seeds per kg (Bhat et al., 2004).

Nursery technology

The seeds are soaked in normal water for 36 hours before sowing. Treated seeds were sowed in the motherbed during June – July and covered with sand. Regular irrigation and weeding is done. Germination starts in a week and the

germination percent around 45 to 65 percent in five weeks. From one year old seedlings, the stumps can be prepared for planting.

Soft wood cuttings (3-5 nodes with 10 cm length) were treated with 0.2 percentbavistin and 3000 ppm IBA. It is planted in the soil sand ratio of 1:1 under mist chamber having 90-95 % humidity and 40-45 $^{\circ}$C temperature (Prabakaran et al., 2017). The rooting will be started after 25 days after planting. The rooted cuttings were kept in hardening chamber for 3 months to out planting in the field.

Plantation technology

The Bushes were cleared using bull dozer in case of non-agriculture land. Two disc ploughing for the compact field. Two to three cultivators ploughing are required for agriculture field and then levelled using tractor. The pitting (30 cm^3) was taken in duringthe month of May in the spacing of 3 x 3 m. The pit was enriched with 500g of FYM or 250 g of Vermicompost for each pit. The three to four months old seedlings were in the field during June – July. Causalities were replaced within one month after planting. For once in two days drip irrigation or once in a week channel irrigation is done for better growth.One rotavator ploughing to suppress weed growth for once in 3 months followed by one hand weeding and soil working. The branches were pruned up to 1/3rd of the stem height during six months after planting. 1 kg of urea and 1 kg of Muriate of potash are solubilised in the water are passed through the fertigation system in once in a month.

Medicinal value

The various parts of *Lannea coromandelica* is extensively used in Indian system of traditional medicine by rural folklore. The leaves contains alkaloids, flavonoids, glycosides, phenolics and terpenoids, hence it is used to cure coma due to debility, dyspepsia, dysentery, gout, impotency, leprosy, narcotics, ulcers, sore eyes and sprains (Upadhyay et al., 2010; Reddy et al., 2011; Kaur et al., 2013). Extracts of leaves were used to diarrhoea, elephantiasis, hematochezia, snakebite, stomach ache, tooth ache and ulcer (Franco and Narasimhan, 2009). Twigs of *Lannea* were used as tooth sticks in rural India. The barks extracts has aphrodisiac, astringent, anti-inflammatory, hypotensive wound healing, zoosporicidal properties (Sathish et al., 2010). Gum from Lannea or *jhigam* gum is used in treatment of asthma, sprainsand also beneficial for the lactating women (Reddy et al., 2011).The crushed fruits were used as fish poison by tribals of India. The roots were used in brews and also used as the medicine for stomach ache (Franco and Narasimhan, 2009).

***Jhingan* gum**

A mucilaginous gum exudes from wounds and cracks from the barks of *Lannea coromandelica* known as *Jhingan* gum. It looks like round tears or colourless fissured angular fragments. It is yellowish white when fresh, turning into brown in colour and finally turns into black on drying sometimes glassy whitish colour also (Reddy et al., 2011). Fresh gums were soluble in water forming instead of sticky with good adhesive. Trees having more than 40 cm diameter can be used for the gum extraction by borehole method (5 cm depth made inside tree stem) with 300mg/ml *Ethephon* will resulted in higher yields (Vasishth, 2017). The gums were usually tapped during the February to June tapping season. The Jhingan gum is used

in calico printing, confectionaries, inferior varnishes and inks, plastering, sizing of cloth and paper, white washing and also preservation of fishing nets. It can be used as a flocculating agent for the sugar cane juice which aids the fast settling of impurities and yields abright and clear juice. *Jinghan* gum combined with the basic binding material called *Jigat* (bark of *Machilus macrantha*) in 1:1 ratio was a good partial substitute and also reduces the 20% cost of agarbathis making than with pure *Jigat*. The cost of *Jhingan* gum collection will ranges from Rs. 2000 to 5000/qt (Yogi et al., 2017).

Timber

The wood of *Lannea coromandelica* is light, moderately hard and close-grained in nature. The heartwood of *Jhingan* is reddish brown in colour while the sapwood is pale colour. The wood is diffuse-porous and either solitary or radial multiple vessels were present. It has a scanty and vasicentric parenchyma. Fibres are septate with simple pits mainly confined to the radial walls. Radial canals are present with 2–3 layers of partly lignified thin-walled epithelial cells, in some rays two radial canals present. Aggregate crystals of silica bodies are present in the ray cells which are present in procumbent and marginal ray cells and idioblasts (Gupta and Agarwal, 2008). Tyloses are present in the heartwood. Since, it has a density of 0.919gm/m^3 at 12 per cent moisture content which is considered to be non-durable to decay (Rahman et al., 2013). Seasoning of *Lannea* wood will causes some defects, which can be used to manufacturing of modified wood such as plywood and particle board. It is used for manufacturing of spear shafts, scabbards, wheel-spokes, oil presses, grain pounders, carvings and turnery, furniture, light packing cases, cooperage etc. The cost of *Jhingan* wood ranged from Rs. 7000 to 8000/tons. It is also has excellent bleachable pulpwood qualities.

Fuel wood

Lannea is one of the excellent fuels with fuel wood value index (FVI) of 1810.73± 57.23. It has calorific value of 25.01± 0.13 KJ/g dry weights, wood density of 0.919± 0.05 g/m3 ash content of 1.27± 0.20 %, biomass/ash ratio of 31.10±7.48and Moisture content of 60.50±12.46 % (Kumar et al., 2011a). It is used as a charcoal and fuel in rural households and industrial purposes.

***Lannea*in agroforestry**

The leaves of *Lannea coromandelica* can be used to rear wild silkworms also. The hedge rows of *jhingan*is planted with between agricultural crops like sorghum, turmeric, etc. It can be planted as live fence around the farm which protects the agricultural crops from wind, storm, sunlight etc. It has deep root system which pumps the nutrients and water from deeper layers. It further helps the understorey crops to withstand drought during summer season. It can be effectively used to train vines of pepper (*Piper nigrum*) and betel (*Piper betle*). It will give partial shade, which is amenable for raising understorey shade tolerant crops such as cardamom, cinnamon, coffee, cloves, nutmeg, tea, turmeric and other fruit trees.

Conclusion

The current status and potential of *Jhingan* is not much understood or aware among farming communities. So there is a need to undertake necessary steps to be taken for promote their cultivation by selection of elite trees, potential areas, development of

modern scientific methods, value addition and marketing.

Reference

Bhat, D. M. Ravindranath, N. H. and Swamy V. S. (2004). Nursery Manual for Forest Tree Species. Universities Press, 329 p.

Franco, M. F. and Narasimhan, D. (2009). Plant names and uses as indicators of knowledge patterns. Ind. J. of Tradit. Knowl. 8(4), 645-648.

Gupta, S. and Agarwal, M. (2008). Wood anatomy of Anacardiaceae from India with special reference to systematic position of Rhus. Int. Assoc. of Wood Anat. J. 29(1): 79-106.

Kaur, R., Jaiswal, M. L. and Jain, V. 2013. Protective effect of *Lannea coromandelica* Houtt. Merrill. against threecommon pathogens. J. Ayurveda Integr. Med., 4:224-8.

Kumar A. R., Jyothi, M.J.and Kumar, A. C. K. 2011. *Lannea coromandelica*: The Researcher's Tree. J. of Pharm. Res., 4(3): 577-579.

Kumar, J. I. N., Patel, K., Kumar R. N. andBhoi, R. K. 2011a. An evaluation of fuelwood properties of some Aravallymountain tree and shrub species of Western India.*Biomass and Bioenergy*, 35: 411- 414. doi:10.1016/j.biombioe. 2010.08.051.

NRCAF. (2013). Vision 2050. Natonal Research Centre for Agroforestry, Jhansi, India. p. 30.

Prabakaran, P., Kanna, S.U., Parthiban, K.T., Rajendran, P. and MahendranS.2017. Macropropagation of Lannea coromandelica (Houtt.) Merr. clones. Electr. J. of Plant Breed. 8(3): 764-771.DOI: 10.5958/0975-928X.2017.00117.X.

Rahman, K.S., Shaikh, A. A., Rahman, M. M., Alam, D.M.N. and Alam,M. R. (2013). The potential for using stem and branch of Bhadi (*Lannea Coromandelica*) as a lingo cellulosic raw material for particle board. Int. Res. J. of Biol. Sci. 2(4): 8-12.

Sathish, R., Hasib, M.A., Natarajan, K. andLalitha, K. G. (2010). Evaluation of wound healing and antimicrobial activity of *Lannea coromandelica* (Houtt) Merr. J. of Pharm. *Res.* 3(6): 12-25.

Upadhyay, B., Parveen.R., Dhaker, A. K. and Kumar, A. (2010). Ethnomedicinal and Ethnopharmaco-statistical studies of Eastern Rajasthan. Ind. J. of Ethnopharmacol.129 (1): 64-86.

Vasishth, A. (2017). Standardization of tapping techniques of gum extraction in *Lannea coromendelica*: a valuable gum yielding tree. Ind. For. 143 (4): 375-379.

Yogi, R. K, Alok, K. and Jaiswal, A. K. (2017). Lac, Plant Resins and Gums Statistics 2015: At a Glance. ICAR-Indian Institute of Natural Resins and Gums, Ranchi (Jharkhand), India. Bulletin (Technical) No. 17/2017. 72p.

Water management in vegetable crops for higher productivity

Abdul Majid Ansari, Ekhlaque Ahmad and D.N. Singh

Zonal Research Station, Birsa Agricultural University
Chianki, Palamau Jharkhand, India.
E-mail: majid.gbp@gmail.com

Water is essential for the biological process of all living organism including plants and vegetable crops. In plant it is absorbed by roots from soil by osmosis and diffusion. Plant nutrients are also taken up from the soil along with water which moves upwards through xylem vessels to different plant parts, like stems and leaves, by translocation. Various physiological processes in plants are directly related with the water such as translocation of nutrients and foods, photosynthesis, respiration, transpiration utilization of minerals and cell division in plants.

The crop plants required water almost throughout the growing period. However, the water-use is critical at certain specific growth periods of the vegetable crops which vary with the crop species. The water available to the plants should neither be in excess nor shortage as both are harmful to the crop plants. There are two main sources of water for the crop plants viz. rainfall water and irrigation water. Vegetables are mainly concern with the irrigation water, because rainfall water is not sufficient for the cultivation of most of the vegetable crops. Rainfall pattern in India is generally very erratic and uneven which is not fit for the optimum requirement of the vegetable crops. Therefore, vegetable crops generally need certain irrigation for effective cultivation in different growing seasons. Regarding the suitability of the irrigation for different vegetable crops various findings are available which are very much useful for the vegetable growers for scheduling the irrigation in the vegetable crop fields at very critical period to optimize the yield of vegetables. With the advancement of science and technology modern vegetable cultivation technique is also very much advanced and its irrigation scheduling and technique of irrigation is also well defined. Now various methods of irrigation have been developed with the advancement of the technique and conventional method of irrigations are shifted toward the micro-irrigation in the hi-tech horticulture system. In the protected cultivation generally drip and sprinkler system of irrigation are used which are very much effective for the protected cultivation of vegetable crops. It is very much helpful to increase the water use efficiency of the crops.

India is the country of diversity not only to its habitat but also regarding the geographically, climatologically, topographically, rainfall pattern as well as the soil type which create a greater diversity of the vegetable crop cultivation in the country. This is the cause for the India's position as second largest producer in the world after China with 133 million tons. Different states of the country are also contributing in different way regarding the area, yield and productivity which are summarized in the table-1.

Table-1: State wise area, production and productivity of vegetables 2009-10

State	Area (000 ha)	Production (000 MT)	Productivity (t/ha)
West Bengal	209.0	2861.00	13.70
Uttar Pradesh	356.7	5380.10	15.10
Bihar	293.6	3484.90	11.80
Orrisa	302.1	1845.00	6.10
Tamil Nadu	291.6	6379.00	21.90
Gujrat	352.9	6985.90	19.80
Karnataka	351.0	5712.40	16.30
Maharastra	1540.6	10396.6	6.70

Source: Horticulture Database 2010

The overall agriculture pattern and position of vegetable crops in India is enlisted as follows:

- Total geographical area 328 m ha.
- Average annual rainfall 112 cm.
- Total annual precipitation 3.7 lakh million cubic meters.
- South-westerly monsoon contributes over 80% to the total precipitation in the country.
- Annual precipitation 0.8 lakh million cubic meters seeps into the ground.
- lakh million cubic meters flows into the rivers 1.2 lakh million cubic meters evaporates back into the atmosphere
- Area under vegetable cultivation is 7.86 million hectare
- Total production is about 133 million tones with 16.2 t/ha.
- Vegetable crop breakthrough by value is about 18%.
- Yield of important vegetables viz. Potato 36 m. tones; tomato 12 m. tones; brinjal 10 m. tones etc.
- More than 80% vegetable growers are poor and marginal farmers.
- Use of vegetable produce for processing is less than one percent in India.
- Post-harvest losses of vegetable are still about 30 % in the country.
- Proper marketing and transportation facilities are still a major problem in India.

Classification of vegetable crops

On the basis of water requirement, rooting depth and irrigation requirement and critical stages, the vegetable crops can be classified under the following major groups, which are enlisted in the table No-2, 3, 4, & 5.

Table 2: Classification of vegetables according to their water requirement

High	Moderate	Low	Very Low
Palak	Onion	Pea	Watermelon
Amaranths	Cucumber	French bean	Muskmelon

Lettuce	Chilli	Cowpea	Pumpkin
Celery	Brinjal	Broad Bean	Wax gourd
Sweet pepper	Tomato	Cluster bean	
Cabbage	Carrot	Winged Bean	
Cauliflower	Potato	Hyacinth Bean	
Asparagus			
Broccoli			
Beet			
Turnip			
Green onion			

Table 3: Rooting depth of different vegetable crops

Very shallow rooted	**Shallow rooted (30-60cm)**	**Moderately deep rooted (60-90cm)**	**Deep rooted (90-120cm)**	**Very deep rooted (120-180cm)**
Onion	Broccoli	French bean	Pea	Artichoke
Lettuce	Brussels sprout	Beet	Chilli	Asparagus
Small radish	Chinese cabbage	Carrot	Summer squash	Lima bean
	Cauliflower	Chard	Rutabaga	Parsnip
	Celery	Cucumber	Turnip	Winter squash
	Endive	Brinjal		Sweet potato
	Leek	Muskmelon		Tomato
	Parsley			
	Potato			

Table 4: Requirement of Irrigating Water for Some Vegetable Crops

Very Shallow to deep rooted	**R* (Acre inch)**	**Moderately deep to deep- rooted**	**R* (Acre inch)**	**Very deep rooted**	**R* (Acre inch)**
Onion	15	Pole bean	15	Artichoke	12
Lettuce	18	Beet	18	Lima bean	12
Cabbage	12	Carrot	18	Sweet potato	18
Cauliflower	12	Cucumber	15	Tomato	24
Celery	30	Brinjal	18		
Potato	30	Muskmelon	24		
Spinach	9	Pea	18		

Note: Acre-inch X 102.8= Cubic meter

(Source: Shanmugavelu, K.G.1993. Production Technology of Vegetable Crops)

Table 5: Critical Stages of Irrigation in Some Vegetable Crops

Crops	Stages of crop
Tomato	Flower development, fruit set and after each harvest
Brinjal	Same
Chilli	Tenth leaf to flower, fruiting and after periodical harvest
Potato	Stolon formation, tuberization and tuber enlargement
Pumpkin, Cucumber, Watermelon, Gourds, Muskmelon, summer squash	Flower bud development and early fruit development
Cabbage	Head formation and enlargement
Cauliflower	Through whole vegetation period

Frequency of irrigation in vegetable crops

Irrigation schedule and its frequency is very much important for the optimum yield of the vegetable crops various recommendations for different region of the country given for different crops are enlisted in the table No. 6

.

Table 6: Frequency of irrigating vegetable Crops

Okra	Delhi	3-6	Summer
		10-12	Winter
Muskmelon	Ludhiana	7	Summer
Watermelon	Bangalore	7-10	Summer
	General	8-10	
Bitter, Sponge, Ridge gourd, Round gourd	General	4-5	Summer
Onion	Pune	13	Nov-Dec
		10	January
		7	Feb.- March
	Delhi	16 (Sandy loam)	--
		12 (Sandy loam)	---
	General	12-15	October planting
		15-20	Summer

Traditional systems and method of irrigation

Various traditional methods of irrigation systems have been developed for the different vegetable crops and recommended for different agro-ecological zones in different ways which are very much useful for the successful cultivation of the vegetable crops in different season. Still to dates most of the vegetable crops are irrigated in traditional way only protected cultivation and some advanced region of the vegetable growers are utilizing the micro-irrigation system.

Hence, the traditional systems are still important for the vegetable cultivation along with the modern hi-tech systems of irrigation. Because more than 80% farmers of the country are poor and marginal and they are not in a position to afford the high cost of the establishment of the micro irrigation system. Although various schemes are available for the popularization of the hi-tech system of irrigation and vegetable cultivation but slow response of the farmers shows still required prime attention for the researchers and planners of the country. It does not mean to ignore the micro-irrigation system but it is fact that the tradition system is still a need of the existing condition of the vegetable growing pattern in the marginal and poor farmers. The various systems of the irrigation including traditional system of irrigation for the vegetable crops are;

- Sub-irrigation or Sub surface irrigation
  - Flooding: well labeled field
  - Furrow: Planting on ridges or raised beds
  - Ring & basin method: Cucurbits
- Pitcher irrigation, Pot watering river bed cultivation at early stage of seed germination
- Drip irrigation
- Sprinkler irrigation

Pitcher or pot irrigation

Pitcher irrigation consists, in its simplest form, of unglazed baked earthen pitchers which are buried to their neck in the soil and filled with water. The water gradually sweeps out through the porous walls into the root zone under hydrostatic pressure and/or suction, to maintain plant growth around the pitchers.

Use of drip irrigation

- Strawberry, Kiwi, Lemon, Banana, Apple, Pomegranate and Guava etc.
- Tomato, Pea, Cauliflower, Okra, Cabbage, Broccoli, French bean, Capsicum etc.
- All type of flower crop

Components of drip irrigation

- Pump or pressurized water source
- Water Filter(s) - Filtration Systems: Sand Separator, Cyclone, Screen Filter, Media Filters
- Fertigation Systems and Chemigation Equipment (optional)
- Backwash Controller
- Main Line (larger diameter Pipe and Pipe Fittings)
- Electronic, hydraulic, or Hand-operated Control Valves and Safety Valves
- Smaller diameter polyethylene tubing (often referred to as "laterals")
- Poly fittings and Accessories (to make connections)
- Emitting Devices at plants (ex. Drippers, micro spray heads, irrigation mats)
- Drip irrigation systems may be manually operated or may be automatically operated by a controller with electric or hydraulic actuated valves.

Benefits of fertigation over traditional broadcast

Following benefits are enlisted for the fertigation over the traditional broadcast of the fertilizers in vegetable crops;

- Increased nutrient absorption by plants
- Reduction in fertilizer and chemicals needed

- Reduced leaching to the water table and,
- Reduction in water usage due to the plant's resulting increased root mass being able to trap and hold water.

These benefits are evident from the table-7 showing the results of garlic experiment.

Table 7: Fertigation in garlic at RRS, Karnal during Rabi 2005-06

Treatments	Gross Yield (q/ha)	Mrkt. Yield (q/ha)	TSS (%)	Dry Matter (%)
T-1Rec. NPK through drip	130.55	115.97	39.67	41.42
T-2 90% of Rec. NPK through drip	124.47	112.33	39.00	41.18
T-3 80%Rec NPK through drip	117.01	102.25	38.83	40.33
T-4 70%Rec NPK through drip	113.71	91.84	38.44	40.10
T-5 60%Rec NPK through drip	102.08	77.60	37.87	39.26
T-6 100 Rec.P & K through band placement & N in 7 splits through drip	125.52	114.58	39.33	40.91
T-7100 % Rec. NPK through band placement in drip	114.42	108.88	38.83	40.48
SEm+	1.57	1.93	0.42	0.18
CD at 5%	3.37	4.14	0.90	0.39

Table 8: Drip irrigation scheduling in broccoli

Treat.	Plant Height(Cm)	No. of green leaves per plant	Green leaves wt/plant(g/plant)	Per head weight(g)	Yield (q/ha)
T1	80.7	16.8	875	277. 00	107.9
T2	77.47	19.8	862.5	269.5	97.21
T3	76.05	16.6	865	2290.5	09.41
T4	77.15	15.0	910	317.5	20.41
T5	75.2	16.6	950	319.0	22.51
T6	77.7	15.8	1037	348.0	28.01
T7	84.2	17.2	112.5	304.7	14.3

Advantage of drip irrigation

- Minimized fertilizer/nutrient loss due to localized application and reduced leaching.
- High water distribution efficiency.
- Leveling of the field not necessary.
- Allows safe use of recycled water.
- Moisture within the root zone can be maintained at field capacity.
- Soil type plays less important role in frequency of irrigation.
- Minimized soil erosion.
- Highly uniform distribution of water i.e., controlled by output of each nozzle.

- Lower labour cost.
- Variation in supply can be regulated by regulating the valves and drippers.
- Fertigation can easily be included with minimal waste of fertilizers.
- Early maturity and a bountiful harvest

Table 9: Relative performance of micro irrigation compared to traditional system

Crop	Yield (q/ha)		Irrigation (cm)		WUE (q/ha/cm)		Adv. Of MI	
	Surface	Drip	Surface	Drip	Surface	Drip	Saving	Inc. in yield
Cauliflower	171.00	274.00	27.00	18.00	6.30	15.20	33.30	28.40
Tomato	104.00	137.00	22.00	14.00	4.70	9.80	36.70	33.30
Brinjal	280.00	320.00	90.00	42.00	3.11	7.60	53.30	12.50
Bottle gourd	380.00	558.00	84.00	74.00	4.50	7.50	12.00	31.90
Chilli	42.30	60.90	109.00	41.70	0.39	1.50	61.70	30.50
Okra	360.00	480.00	42.00	26.00	8.60	18.50	38.10	25.00
Potato	235.70	344.20	20.00	20.00	11.80	17.20	0.00	31.50
Onion	284.00	342.00	52.00	26.00	5.50	13.20	50.00	27.00

Disadvantage of drip irrigation

- Expense Initial cost can be more than overhead systems.
- The plastic tubing and "tapes" generally last 1-3 seasons before being replaced.
- Clogging, if the water is not properly filtered and the equipment not properly maintained.
- Drip irrigation might be unsatisfactory if herbicides or top dressed fertilizers need sprinkler irrigation for activation.
- Drip tape causes extra cleanup costs after harvest. You'll need to plan for drip tape winding, disposal, recycling or reuse.
- Waste of water, time & harvest, if not installed properly.

Drip irrigation not only saves water but improves the quality of the produces as evident from the following table.

Table 10: Quality parameters of tomato as influenced by drip irrigation at various locations in India

Location	System	Ascorbic acid content (mg/100g)	Acidity (%)	TSS Brix (%)	Total sugars (%)	Sugar acidity ratio	Carotenoides mg/100g)
Coimbatore	Drip	25.41	0.57	4.60	2.97	5.18	9.70
	Surface	20.90	0.58	4.60	2.81	5.38	9.07
Navsari	Drip	23.89	0.54	4.30	2.89	5.04	9.50

	Surface	21.40	0.55	4.30	2.72	5.03	9.12
Gayeshpur	Drip	24.37	0.55	4.80	3.12	5.21	9.93
	Surface	22.09	0.57	3.90	2.89	5.11	8.69
Overall Average	Drip	24.56	0.55	4.57	2.98	5.14	9.71
	Surface	21.46	0.57	4.27	2.81	5.17	8.96

Source: Samra, 2005

Sprinkler irrigation

- Method of applying irrigation water which is similar to natural rainfall.
- Water is distributed through a system of pipes usually by pumping.
- It is then sprayed into the air through sprinklers so that it breaks up into small water drops which fall to the ground.
- The pump supply system, sprinklers and operating conditions must be designed to enable a uniform application of water
- Sprinkler irrigation is suited for most row, field and tree crops and water can be sprayed over or under the crop canopy.
- Large sprinklers are not recommended for irrigation of delicate crops such as lettuce because the large water drops produced by the sprinklers may damage the crop
- Sprinklers are best suited to sandy soils with high infiltration rates although they are adaptable to most soils.
- The average application rate from the sprinklers (in mm/hour) is always chosen to be less than the basic infiltration rate of the soil (see Annex 2) so that surface ponding and runoff can be avoided.
- Sprinklers are not suitable for soils which easily form a crust. The larger sprinklers producing larger water droplets are to be avoided.

Parts of sprinkler

1. Pump unit
2. Mainline and sometimes sub mainlines
3. Laterals
4. Sprinklers

Function of sprinkler system

- Drop size is also controlled by pressure and nozzle size. When the pressure is low, drops tend to be much larger as the water jet does not break up easily.
- Use small diameter nozzles operating at or above the normal recommended operating pressure.
- As water sprays from a sprinkler it breaks up into small drops between 0.5 and 4.0 mm in size.
- The small drops fall close to the sprinkler whereas the larger ones fall close to the edge of the wetted circle.
- Large drops can damage delicate crops and soils and so in such conditions it is best to use the smaller sprinklers.
- Sprinkler system has been found beneficial for legume vegetables like pea which require very less amount of water.

Conclusion

- Vegetables are short duration crop; therefore, they require frequent & efficient irrigation.
- Micro- irrigation is efficient in saving water as well as fertilizers.

Diversity of macro-fungi in central India-X: Edible mushrooms *Macrocybe crassa* and *Macrocybe lobayensis*

R.K. Verma, A.K. Thakur and Vimal Pandro

Forest Pathology Division
Tropical Forest Research Institute
Indian Council of Forestry Research and Education, Ministry of Environment, Forest and Climate Change
Jabalpur - 482 021, Madhya Pradesh
E-mail: vermaramk@icfre.org

Introduction

Genus *Macrocybe* was erected to accommodate species previously placed in *Agaricus* and *Tricholoma* (Pegler et al., 1998) and seven species have already been accommodated under this genus till date. Out of which 5 species (*M. crassa*, *M. gigantean*, *M. lobayensis*, *M. pachymeres* and *M. titans*) are reported from India (Massee, 1912; Manimohan et al., 2007; Mohanan, 2011; Vrinda et al., 1997). *M. crassa* is also reported from Japan, Thailand and Sri-Lanka (Huffman et al., 1989). In Thailand, *this mushroom* has various common names among local people (Petcharat, 1996). Natural occurrence of *M. crassa* is generally rare, because it is usually found only once a year, particularly in the rainy season. *M. praegrandis* (Berk.) Pegler & Lodge grows amongst grasses in Brazil. *M. spectabilis* (Peerally and Sutra) Pegler and Lodge is reported from Japan, Mauritius and Hawaii (Pegler et al., 1998). Many macro-fungi including some edible fungi were recently reported from central India (Pyasi et al., 2011; Verma 2014, 2015; Verma and Verma 2017ab; Verma et al. 2017abc)

In the present article two species of *Macrocybe*, namely *M. crassa* (Sacc.) Pegler & Lodge and *M. lobayensis* (R. Heim) Pegler & Lodge are reported from the first time from central India (Jabalpur, Madhya Pradesh).

Materials and methods

Specimens were collected from Jabalpur, Madhya Pradesh, India. Identification of fungi was done with the help of literature (Berkeley and Broome, 1871; Chakravarthy and Sarkar, 1982; Chang and Miles, 1989; Henkel et al., 2004; Huffman et al., 1989; Largent, 1977; Manimohan et al., 2007; Mohanan, 2011; Pegler et al., 1998; Petcharat, 1996; Ramirez et al., 2017; Vrinda and Pradeep, 2006). The slides were prepared in lacto-phenol and cotton blue and observed under advance Research Microscope, make Leica, Germany and photomicrographs were taken with a digital camera attached to the microscope. The specimens were deposited in the Mycology Herbarium, Tropical Forest Research Institute, Jabalpur and got accession numbers.

Results

Taxonomic description

***Macrocybe crassa* (Sacc.) Pegler & Lodge (Figures 1-7)**

≡*Tricholoma crassum* Sacc., *Syll. fung.* (Abellini) 5: 109 (1887) ≡*Agaricus crassus* Berk. 1847 (replaced synonym) non *Agaricus crassus* Scop. 1772 (Tricholomataceae, Agaricales, Agaricomycetidae, Agaricomycetes, Agaricomycotina, Basidiomycota) Basidiomata solitary or caespitose. Pileus

14-24 cm diam, convex to obtusely umbonate or almost applanate, finally becoming slightly depressed; surface pale cream, yellowish brown to grayish brown, darker at center, smooth, drying minutely cracked and sometimes splitting radially; margin involute, weakly crenate. Lamellae adnexed to sinuate, white to pale cream, 4-10 mm broad, crowded, with lamellulae of two lengths. Stipe 15-25 x 1.4-5 cm, cylindrical in apical region while swollen at base; solid then fistulose; surface off-white, with grayish-brown fibrillose streaks (Figs. 1-3). Context up to 3.5 cm thick at disc, white, firm; consisting of thin-walled hyphae, 2-6 µm diam, inflated to 20 µm diam, with clamp connections; taste slightly bitter; odor 'ammoniacal'. Basidia 25-30 x 7-8 µm, clavate, bearing four sterigmata (Figs. 4-7). Spore deposit pale cream. Basidiospores ovoid, hyaline, inamyloid, thin-walled, smooth measuring 5.0-6.5 x 3.7-4.5µm. Hymenophoral trama regular, with hyphae 3-5 µm diam. Subhymenial layer 7-12 µm thick, hyphae narrow, interwoven. Pileipellis a repent cutis, of thin-walled, uninflated hyphae, 5-7µm diam.

Collections examined

Growing on heap of dead organic waste near road side, 4th Miles, Mandla Road, Jabalpur, 14.6.2013, KK Soni. Tropical Forest Research Institute Jabalpur, TF-3463.

Distribution

This mushroom is reported from Asian region—in Japan, Thailand and Sri-Lanka (central Province, Kandy); Peradeniya; Selangor, Kuala Lumpur, Malaysia; Calicut, Kerala, India, Bangkhen, Bangkok, Thailand.

Economic importance

It is cultivated on horse manure and sawdust and sold in market. Natural *M. crassa* is generally rather rare and found only once a year during rainy season. It can be easily cultivated on rubber tree sawdust. Collections from Malaysia are reported to be edible after removing the bitter taste by cooking.

Figure 1: *Macrocybe crassa* growing fruit bodies

Figure 2: ***Macrocybe crassa,*** sporophores, pileus upper surface

Figure 3: ***Macrocybe crassa*** gills layer and attachment with stalk

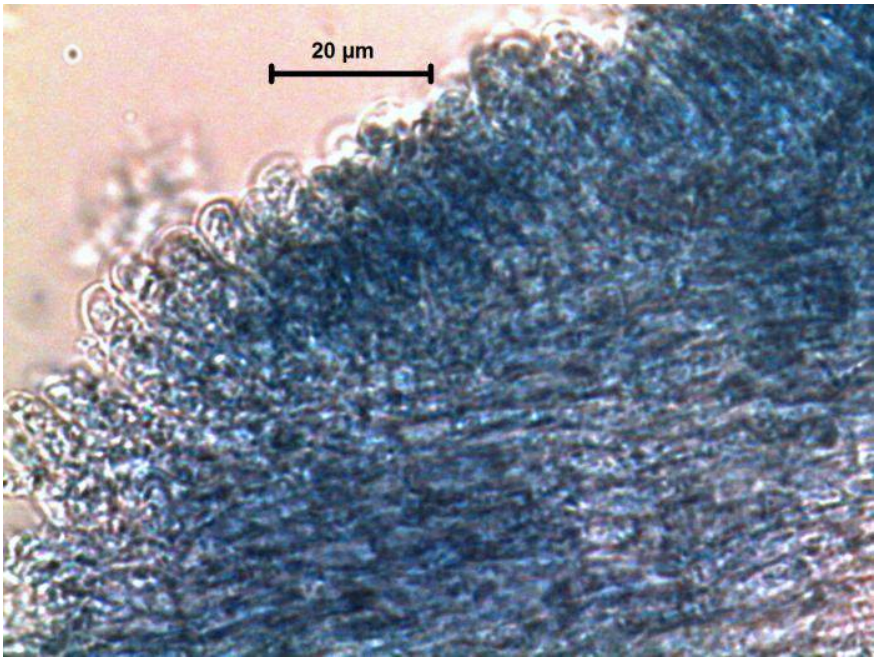


Figure 4: ***Macrocybe crassa,*** basidial layer

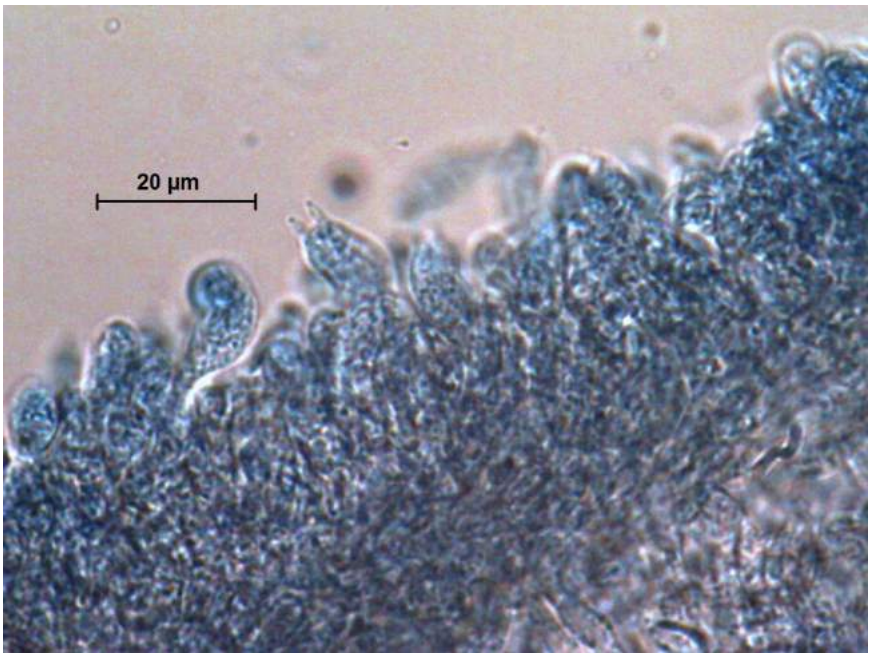


Figure 5: ***Macrocybe crassa,*** basidia

Macrocybe lobayensis **(R. Heim) Pegler & Lodge** (Fig. 6-11).

≡*Tricholoma lobayense* R. Heim 1970

Taxonomic Description

Basidiome medium to large sized. Pileus 8-14.5cm diam. Fleshy, convex to applanate, surface white with pale grayish tints, glabrous, smooth, non- striate, margin lobed, enrolled. Lamellae adenate to sinuate, cream color with pale pink hints, narrow up to 2mm broad, moderately crowded, with lamellulae of 5 lengths, edge entire 1cm in 15 lamellae. Stipe 4-10 × 2-3cm cylindrical with a swollen base, solid, finally fistulose; surface white to pale grayish, fibrillose, rugose to glabrous, arising from a buried pseudo sclerotium (Figs. 6-7). Spore print

white (Fig. 8). Basidia 25-32×3.5-6µm narrowly clavate, bearing 4 sterigmata (Fig. 9), basal clamp-connection. Basidiospores 6-8×4-5 µm ovoid to broadly ellipsoid, hyaline thin walled (Figs. 10-11). Containing single large refractive guttule. Lamella edge heteromorphous cheilocystidia rare, 28-37×5-8.5 µm, clavate- cylindrical with granular contents. Caulocystidia 40-50×5-8.5 µm clavate, thin-walled, hyaline

Collections examined

Attached with trunk of *Ficus religiosa*, 20.7.2012 Jabalpur, MP, collected by Yankesh Khare, R.K. Verma. Tropical Forest Research Institute Jabalpur, TF-2813

Distribution

Distributed in tropical forest of the state and moist-deciduous to semi-evergreen forest occurs scattered in large caespitose clusters on humus rich soil. Reported from Western Ghats of Kerala and also reported from Uttarakhand as *Tricholoma lobayense*.

Economic importance

This is an edible mushroom after parboiling and thorough cooking.

Figure 6: ***Macrocybe lobayensis*** habit, fruit body attached to *Ficus religiosa* stem

Figure 7: ***Macrocybe lobayensis*****,** basidiocarp, gill surface

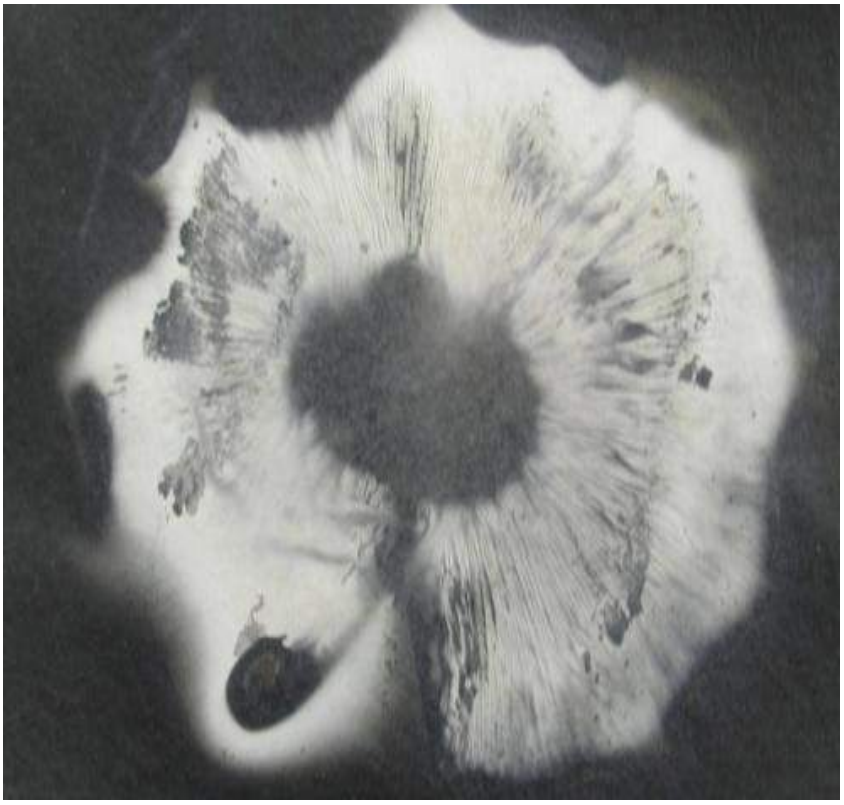


Figure 8: ***Macrocybe lobayensis*****,** spore print

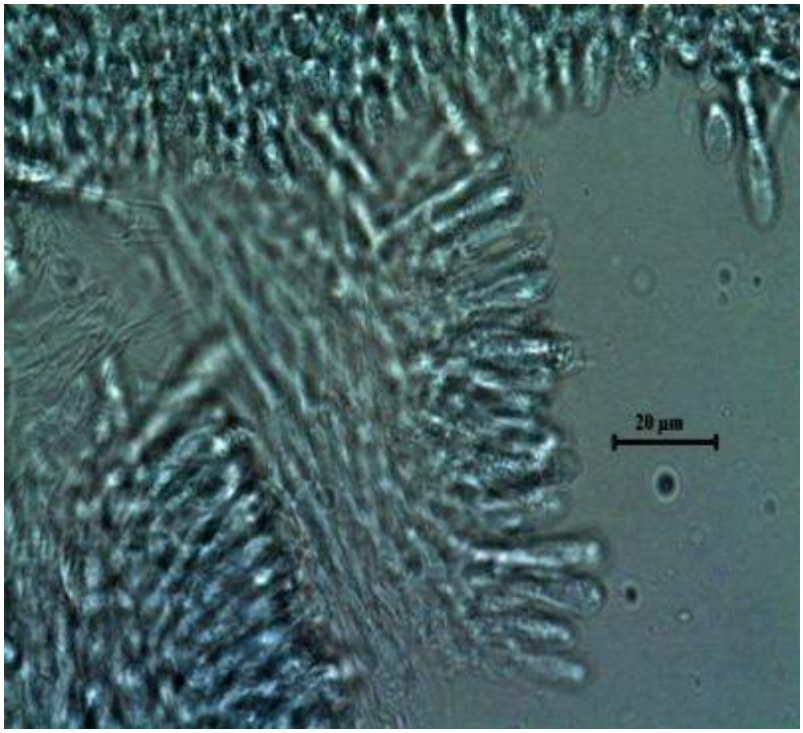


Figure 9: ***Macrocybe lobayensis*****,** basidia

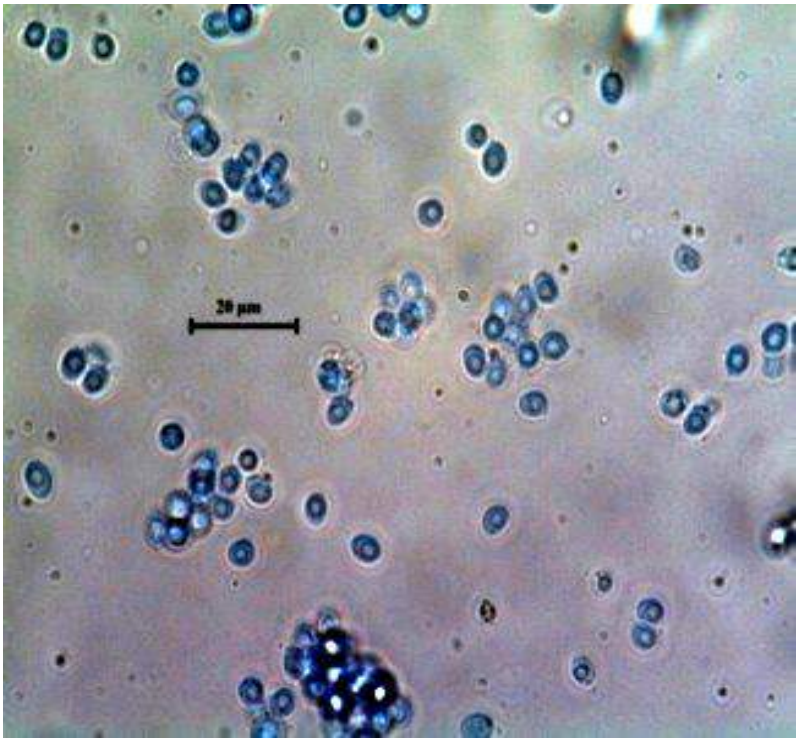


Figure 10: ***Macrocybe lobayensis*** basidiospores

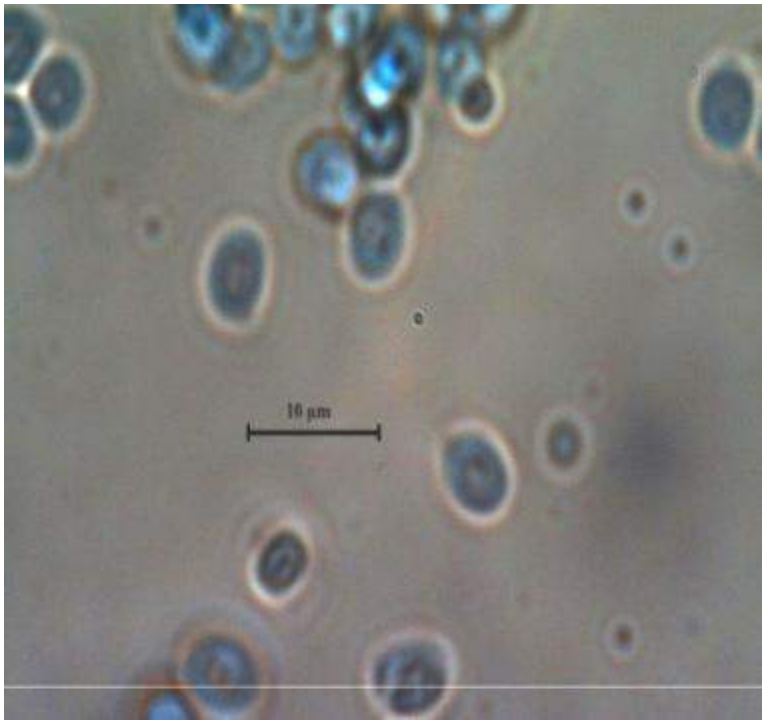


Figure 11: ***Macrocybe lobayensis*** basidiospores (enlarged)

Discussion

Macrocybe species are distributed world-wide (Table 1). *Macrocybe crassa* and *M. gigantea* represent the two largest, tricholomatoid agarics of south-east Asia. The two species can be distinguished by the hymenophore color, the lamellae of *M. gigantea* being straw yellow rather than white, and the stipe that is cylindrical in *M. gigantea* rather than being expanded at the base. *M. lobayensis* earlier reported from Thiruvananthapuram, Kollam and Ernakulam, Kerala and Tamil Nadu while *M. pachymeres* reported as *Agaricus* and *Tricholoma pachymeres* from Thrissur, Kerala (Table 1). Eleven species of mushrooms (Amanitaceae, Cantharellaceae, Clavulinaceae, Sarcoscyphaceae) including *Macrocybe* utilized as a food from rain forest of Guyana were reported (Henkel et al., 2004).

Table 1: Distribution of *Macrocybe* species

S.N.	Name of species	Distribution	Reference
1.	*Macrocybe crassa* (Sacc.) Pegler & Lodge	Sri Lanka, India (Kerala), Malaysia	Inyod et al., 2016
2.	*Macrocybe gigantea* (Massee) Pegler & Lodge	India (Shamnagar, Kolkata, West Bengal), Pakistan, Nepal; Thrissur, Kerala	Manimohan et al., 2007; Massee, 1912
3.	*Macrocybe lobayensis* (R. Heim) Pegler & Lodge	West Africa, India (Jabalpur, Madhya Pradesh; Tamil Nadu; Thiruvananthapuram,	Anandh and Prakasam, 2002; Balakrishnan, Nair, 1998; Vrinda and Pradeep, 2006;

		Kollam and Ernakulam, Kerala)	Mohanan, 2011
4.	*Macrocybe pachymeres* (Berk. & Broome) Pegler & Lodge = *Agaricus* (*Tricholoma*) *pachymeres* Berk. & Br.	Sri Lanka, India (Thrissur, Kerala)	Pegler et al., 1998; Berkeley and Broome, 1871; Mohanan, 2011
5.	*Macrocybe praegrandis* (Berk.) Pegler & Lodge	Brazil	Pegler et al., 1998
6.	*Macrocybe spectabilis* (Peerally & Sutra) Pegler & Lodge =*Tricholoma spectabile* Peerally & Sutra	Mauritius, Japan, Hawaii	Pegler et al., 1998
7.	*Macrocybe titans* (H.E. Bigelow & Kimbr.) Pegler, Lodge & Nakasone	USA (Florida, Puerto Rico), Costa Rica, Argentina, Thiruvananthapuram, Kerala	Ramirez et al., 2017 Vrinda et al., 1997

Artificial cultivation

Use of various substrates media for mushroom cultivation of these mushrooms resulted in different yields. *Macrocybe crassa* was easily and successfully cultivated on rubber tree sawdust (Payapanon and Srijumpa, 2008). Traditional cultivation methods on rubber tree sawdust substrates and to determine their growth and the productivity and characteristics of the fruiting body to identify the best strain of *M. crassa* mushroom most suitable for commercial cultivation. In Bangkok, Thailand mushroom spawns were prepared on sorghum grains. Inoculated grain bottles were tightly secured using moist cotton wool and covered with sterile aluminum foil. They were kept in dark, sterile cabinets at ambient room temperature for 14 d until they were fully colonized. The substrates employed in the production and in-depth mycelial development assessments of *Macrocybe* were prepared using rubber tree (*Hevea brasiliensis*) sawdust mixed with fine rice bran, magnesium sulfate ($MgSO_4.7H_2O$) and calcium oxide (CaO) in the ratio of 100:3:0.2:1 (weight per weight). Water was added to adjust the moisture content to 65%. Samples of the substrate mixture (each approximately 600g) were used to fill 1 kg capacity autoclavable polypropylene bags to only three-quarters of their capacity and then steamed for 3 h in a large cast-iron steamer. When the temperature in the mushroom spawn cooled down to room temperature, 10–15 seeds of grains spawn were added to the bags and incubated at approximately 25°C for spawn running until the bags were fully covered with mycelia. The upper end of the bags was cut off and the spawn mushrooms were neatly arranged in a basket and placed on shelves in the growing room. The surface of the compost was covered with a 2.5–5cm thick layer of steamed casing soil, which was necessary to initiate fruiting. After casing, the relative humidity of the room was

maintained between 85% and 90%. After fructification, one flush of mushrooms in each bag was harvested when the cap had started to fold. The cultivation substrates were maintained for 2 months. Sawdust was considered as the most effective substrate for the production of the five different strains of *M. crassa*. The biological yield was estimated on the basis of 600g substrate. The nutritional contents of strains on sawdust were varied for example protein content were 11.85 - 26.1 mg/kg dry weight, fat content 1.3 – 2.5, ash 11.6 – 12.3, carbohydrate 53.7 – 68.1, crude fiber 2.4 – 2.7 and total β-glucan was 40.8 – 46.6 mg/kg dry weight respectively (Inyod et al., 2016). *Tricholoma lobayense* can be also commercially utilized by artificial cultivation (Anandh and Prakasam, 2002).

Acknowledgement

Authors are thankful to Dr. N. Kulkarni, Director, Tropical Forest Research Institute, Jabalpur for providing necessary facilities and Indian Council of Forestry Research & Education, Dehradun for financial assistance under project ID No. 224/TFRI/2016/Patho-1(22).

References

Anandh, K. and Prakasam, V. (2002). *Tricholoma lobayense*, a new edible mushroom for commercial exploitation. Paper presented in 3rd Indian Mushroom Conference, 6-7 March, 2002, Tamil Nadu Agricultural University, Coimbatore, p65.

Balakrishnan, B, and Nair, M.C. (1998). *Tricholoma lobayense* Heim, a new edible mushroom to Kerala. In: Frontiers in Mushroom Research (eds TK Abraham, NS Pradeep, P Pushpangadan). Tropical Botanical Garden and Research Institute, Thiruvananthapuram, Kerala, 75–78.

Berkeley, M.J. and Broome, C.E. (1871). The fungi of Ceylon. (Hymenomycetes, from Agaricus to Cantharellus). Botanical Journal of the Linnean Society. 11:494-567.

Chakravarthy, D.K. and Sarkar, B.B. (1982). *Tricholoma lobayense*, a new edible mushroom from India. Curr. Sci. 51: 531-532.

Chang, S.T. and Miles, P.G. (1989). Edible Mushrooms and their Cultivation. CRS Press, Boca Raton, FL, USA.

Henkel, TW; Aime, M.C.; Chin, M. and Andrew, C. (2004). Edible mushrooms from Guyana. Mycologist. 18(3): 104–11.

Huffman DM, Tiffany LH, Knaphus G (1989). Mushrooms and Other Fungi of the Midcontinental United States Iowa State University Press, Ames, IA, USA (1989).

Inyod Tanapak, Sassanarakit Suriya, Payapanon Achara, Keawsomapong Suttipum (2016). Selection of *Macrocybe crassa* mushroom for commercial production. Agriculture and Natural Resources 50(3): 186-191.

Largent, DL (1977). How to Identify Mushrooms to Genus I: Macroscopic Features Mad River Press, Eureka, CA, USA.

Manimohan P, Thomas KA, Shiva VS (2007). Agarics on elephant dung in Kerala State, India. Mycotaxon 99: 147–158.

Massee, G (1912). Fungi exotici. Bulletin of Miscellaneous Information, Kew. Pp 253-255.

Mohanan, C (2011). *Macrofungi of Kerala*. Kerala Forest Research Institute, Hand Book # 27, Kerala, India, 597 pp.

Payapanon, A., Srijumpa, N. (2008). Collection and selection of strains of Macrocybe crassum from various sources for commercial production. In: T. Prapong, S. Prapong, K. Imsilp, A. Poapolathep (Eds.), Proceedings of the 46th Kasetsart University Annual Conference, Kasetsart University, Bangkok, Thailand. Pp. 513-520.

Pegler, D.N., Lodge, D.J., Nakasone, K.K. (1998). The Pantropical Genus Macrocybe gen. nov. Mycologia. 90 (3): 494.

Petcharat W (1996). The wild edible mushroom: (VIII) Tricholoma crassum (Berk.) Sacc. cultivation Songklanakarin J. Sci. Technol. 18: 397-406.

Pyasi, A, Soni, K.K. and Verma, R.K. (2011). Dominant occurrence of ectomycorrhizal colonizer Astraeus hygrometricus of sal (Shorea robusta) in Forest of Jharsuguda Orissa. Journal of Mycology and Plant Pathology 41(2): 222-225.

Ramirez, N.A., Niveiro N, Michlig A, Popoff O (2017). First record of *Macrocybe titans* (Tricholomataceae, Basidiomycota) in Argentina. Check List 13(4): 153-158.

Verma RK, Tiwari CK, Parihar J, Verma P (2017a). Diversity of macro-fungi in central India –V. *Tremella fusiformis*. Van Sangyan 4(3): 46-50.

Verma, R.K. (2014). Biodiversity and Conservation of Forest Fungi of Central India. Pp 543-559. In: Kharwar RN, Upadhyay SD, Dubey NK, Raghuwancy R (eds.) Microbial Diversity and Biotechnology in Food Security. Springer, India

Verma, R.K. (2015). Fungal flora of TFRI campus, Jabalpur. Pp 8-15. In: Singh S, Khatri PK, Meshram PB, Subramanyam P, Prakasham U (eds.) Familiarizing with Biodiversity: Notes on systematic of plants and insects. Tropical Forest Research Institute, Jabalpur, India, 268p.

Verma, R.K. and Verma, P. (2017a). Diversity of macro-fungi in central India – IV. *Auricularia auricular-judae*, a neutracetical jelly mushroom. Van Sangyan 4(2): 23-31.

Verma, R.K., Asaiya, A.J.K., Chaoubey Chitra, Pandro Vimal (2017c). Diversity of Macro-fungi in central India-IX: *Laetiporus sulphureus*. Van Sangyan 4(11): 1-6.

Verma, R.K., Rajput, P.S., Pandro, Vimal (2017b). Diversity of Macro-fungi in central India-VIII: *Astraeus hygrometricus*, an ectomycorrhizal and neutraceutical mushroom from sal forests. Van Sangyan 4(10): 18-29.

Verma, R.K., Verma, P. (2017b). Diversity of macro-fungi in central India – VI. *Schizophyllum commune*. Van Sangyan 4(7): 15-23.

Vrinda KB, Pradeep CK, Mathew S, Abraham, T.K. (1997). *Agaricales* from Western Ghats – V. *Mushroom Research* 6(1): 7-10.

Vrinda, K.B. and Pradeep CK (2006). Macrocybe lobayensis, an edible mushroom from Western Ghats of Kerala. Mushroom Research 15 (2):157-158.

प्रोसोपिस जूलीफ्लोराः उत्तम काष्ठ ईंधन

ममता पुरोहित, राजेश कुमार मिश्रा एवं नितिन कुलकर्णी

उष्णकटिबंधीय वन अनुसंधान संस्थान,

(भारतीय वानिकी अनुसंधान एवं शिक्षा परिषद, पर्यावरण, वन और जलवायु परिवर्तन मंत्रालय, भारत सरकार)

मण्डला रोड, ज़बलपुर – 482021 (म.प्र.)

प्रोसोपिस जूलीफ्लोरा (Swartz.) D.C. लेग्युमिनोसी कुल के उपकुल माइमोसेसी का लघु आकारीय कांटेदार अर्ध सदाबहार वृक्ष है । स्थानीय भाषा में यह काबुली कीकर, विलायती खेजरा या विलायती बबूल के नाम से जाना जाता है । मध्य एवं दक्षिण अफ्रीका की मूल निवासी यह वृक्ष प्रजाति अब प्राकृतिक रूप से प्रायः सभी जगह वृद्धि कर रही है । भारत में यह प्रजाति सन् 1950 के दौरान आई और बिना किसी मानव प्रयास के पूरे दक्षिण भारत में फैल गई । पहाड़ी, सदैव पानी भरे स्थानों (water logged) व दलदली भूमि को छोड़कर यह कर्नाटक, तमिलनाडु, आंध्रप्रदेश, राजस्थान, महाराष्ट्र, हरियाणा, उत्तरप्रदेश आदि राज्यों के साल्ट प्रभावित एवं शुष्क क्षेत्रों में व्यापक रूप से पायी जाती है । यह वृक्ष प्रजाति चट्टानी पहाड़ियों, रेतीली एवं सलाइन (pH 11.5 तक) भूमि, रेत के टीलों एवं समुद्र तटीय रेतीले क्षेत्रों में भी वृद्धि कर सकती है । किसी भी वृक्ष प्रजाति में इसके समान शुष्क दशाओं को सहन करने की क्षमता नहीं होती है और न ही किसी वृक्ष प्रजाति में इसके समान कम वर्षा वाले रेतीले क्षेत्रों में सफलतापूर्वक वृद्धि करने की योग्यता होती है । इसके वृक्ष बिना किसी प्रयास के गाँव एवं शहरों की खाली पड़ी पड़ती भूमि पर कब्जा कर लेते हैं । इसमें पुनरुत्पादन बहुत अच्छा होता है तथा पौधे तेजी से वृद्धि करते हैं । इसकी कॉपिस क्षमता भी बहुत अच्छी होती है । सामान्यतः इसके वृक्ष 8 से 12 मीटर तक ऊँचे एवं 90 से.मी. तक व्यास वाले होते हैं । अनुकूल दशाओं में इसकी ऊँचाई 18 मीटर तक देखी गई है ।

वानस्पतिक विवरण

पुष्पन

प्रोसोपिस जूलीफ्लोरा में वर्ष में दो बार पुष्प आते हैं । एक बार फरवरी से मार्च में और दूसरी बार सितम्बर से अक्टूबर में ।

फल निर्माण

इस प्रजाति में वर्ष में दो बार फल्लियां परिपक्व होती हैं। एक बार अप्रैल से जून के दौरान और दूसरी बार नवम्बर से दिसम्बर के दौरान । फल्लियां 10 से 25 से.मी. तक लम्बी तथा 0.5 से 2.0 से.मी. तक चौड़ी होती हैं । अपरिपक्व फल्लियों का रंग हरा होता है जो पकने पर भूरे-पीले रंग की हो जाती हैं । लम्बी एवं पतली फल्लियां पालतू पशुओं का स्वादिष्ट चारा है ।

बीज

प्रत्येक फल्ली में 10 से 35 तक हल्के कत्थई रंग के आबलांग तथा चपटे बीज पाये जाते हैं । बीज कवच पतला होता है । बीजों का विकिरण भेड़ एवं बकरियों द्वारा होता है ।

बीज एकत्रीकरण एवं भंडारण

बीज इकट्ठा करने के लिए वृक्षों से परिपक्व फल्लियाँ तोड़कर पानी में 10-12 दिनों तक डुबाकर रखते हैं । तत्पश्चात बीज निकालने के लिए फल्लियों को सुखाकर पत्थर या लकड़ी से पीटते हैं । प्राप्त बीजों को अच्छी तरह सुखाकर जूट के बोरों, टंकियों आदि में भरकर साफ-सूखे स्थान पर रखते हैं ।

प्रति किलो बीज सँख्या

लगभग 30, 000

अंकुरण प्रतिशत

80 से 90 प्रतिशत

बीज उपचार

बुआई से पूर्व कम समय में अधिक से अधिक अंकुरण के लिये बीजों को तीन प्रकार से उपचारित कर सकते हैं-

1. ठंडे पानी में 48 घंटे तक डुबाकर रखना चाहिए ।
2. उबलते पानी में बीज डालकर ठंडा होने व 24 घंटे तक डुबाकर रखना चाहिए ।
3. बीजों को सल्फ्यूरिक अम्ल (H2SO4) के 20 प्रतिशत घोल में 01 घंटे तक डुबाकर, पानी से अच्छी तरह धोकर बोना चाहिए ।

अंकुरण की अवधि

बीजों को अंकुरित होने में 28 से 30 दिन का समय लगता है ।

रोपणी तकनीक

मिट्टी, रेत व गोबर की पकी खाद के मृदा मिश्रण से भरी पोलीथीन थैलियों में मार्च से अप्रैल के बीच प्रति थैली 2 बीज बोकर आवश्यकतनुसार सिंचाई करते हैं तथा 5 से 6 माह आयु के पाधों का रोपण करते हैं । चट्टानी व सलाइन क्षेत्रों में 01 वर्ष आयु के पौधों का रोपण किया जाता है ।

भारत में इसके प्रवेश के शुरुआती दिनों में इसे पारथीनियम एवं लेन्टाना की तरह जगह घेरने वाली

अनुपयोगी एवं समस्यामूलक प्रजाति समझा जाता था फलस्वरुप इसके उन्मूलन के बहुत प्रयास किये गये। यह देखा गया कि काफी समय, श्रम और पैसा खर्च करने के बाद भी उसको जड़ से खत्म करना बहुत कठिन है। उन्मूलन के दौरान यदि इसके जहरीले कांटो से घाव हो जाये और घाव को बिना किसी उपचार व देखभाल के कुछ दिनों के लिए ऐसे ही छोड़ दिया जाये तो जोखिम बन जाता है। इन्ही सब कारणों से लोगों का ध्यान इसकी लकड़ी को जलाऊ लकड़ी के रूप में उपयोग करने

पर गया और पाया कि प्रोसोपिस जूलीफ्लोरा की लकड़ी लम्बे समय से जंगलों की अंधाधुंध कटाई और कृषि के लिए बिना किसी वैज्ञानिक पद्धति से भूमि के उपयोग के कारण आई जलाऊ लकड़ी की समस्या का कारगर समाधान है क्योंकि ईंधन हेतु प्रोसोपिस जूलीफ्लोरा की लकड़ी -

1. उत्तम जलाऊ ईंधन है।
2. इसका कैलोरिफिक मान 4800 K. Cal./Kg है।
3. लकड़ी धीमे-धीमे प्रायः बिना धुआं के जलती है आर राख भी बहुत कम बनती है।
4. बहुत अच्छा कोयला बनता है।
5. जड़ की लकड़ी भी बहुत कठोर होती है तथा उच्च श्रेणी का जलाऊ ईंधन है।
6. गहरी जड़ों वाली इस प्रजाति का 5 से 7 वर्ष आयु का वृक्ष 10 किलो से ज्यादा जलाऊ लकड़ी देता है।

अतः व्यापारिक उद्देश्य हेतु इस बहुउद्देशीय वृक्ष प्रजाति के विस्तृत उपयोग को देखते हुए लोगों का रुझान इसे व्यापक रूप से उगाने की तरफ़ बढ़ा। जलाऊ ईंधन के रूप में 14 से 16 से.मी. व्यास की लकड़ी का दोहन करना उपयुक्त होता है। ईंधन के लिए आमजन इसे जहाँ कभी भी यह उपलब्ध है जलाऊ लकड़ी इकट्ठा करते हैं। अतः प्रोसोपिस जूलीफ्लोरा जलाऊ लकड़ी का उत्तम स्रोत है।

Promotion of bamboos through agroforestry system

Nanita Berry, Nikita Rai and Sourabh Dubey
Tropical Forest Research Institute
Indian Council of Forestry Research and Education, Ministry of Environment, Forest and Climate Change
Jabalpur (M.P.)
E-mail: berryn@icfre.org

Introduction

Bamboo is a world's fastest growing woody grass belongs to the Poaceace family. India is the second major bamboo producer having 130 species naturally in subtropical and temperate sites. It is a low cost bio-degradable, versatile resource now popularizing as substitute of timber species. Bamboo have an estimated 1500 uses including paper, food (as soup, vegetable and pickle), fuel, charcoal, construction (as building material), hut, furniture, bamboo floor, bamboo cottage, , bamboo fabric, fodder, medicinal products, handicraft items and agricultural tools (Filho and badr, 2004; Pilliere, 2008; Chauhan and Kumar, 2005). Bamboo is not only of economic importance to rural communities in most Asian countries, but also of ecological value in preventing soil and water erosion by its fibrous rhizomes (Bystriakova et al.2003). Earlier bamboo was called as poor man's timber but now it becomes 'Green gold' for the growers, farmers or rural people. It is easily cultivated by rhizome, branches, culms and root cutting.

Although India has a larger area of bamboo than China but unit growing stock per hectare are relatively lower 75 and 30 % respectively its total and due to a different species composition, India reported nearly 3 million hectares of planted bamboos, approximately 25 % of total bamboo resources. The share of planted bamboo remained stable, while the total area of bamboo gradually increased. (Lobovikov et al. 2007)

According to the Forest Survey of India, 2011, total bamboo bearing area is approximately 13.96 million hectare in India. Arunachal Pradesh has maximum bamboo bearing area (1.6m ha) followed by Madhya Pradesh (1.3 m. ha), Maharashtra (1.15m.ha) and Orissa (1.03m.ha). The green marketable culms is maximum in Arunachal Pradesh (12.4 m tonnes) followed by Manipur (11.6 m tonnes), Mizoram (11.2 m tonnes) (Fig.1) and other hand dry marketable culms is maximum in Maharashtra (6.1 m tonnes) followed by Madhya Pradesh (5.7m tonnes), Karnataka (4.7 m tonnes) and Rajasthan (2.7 m tonnes) (Fig.2).

The FSI report (FSI, 2015) revealed that the total forest cover of the country is 701,673 sq. km. which is 21.34% of the geographical area of our country, while forest policy, 1988 emphasis to achieve at least 33% of forest cover.

Present major problem is how to increase green cover of India which can generate option to the rural people, with limited land surface area i.e. 329 million hectare. Other hand rapid urbanization, biotic pressure, climate change and other human activities are main reason for deforestation and responsible for reduction in forest cover of India.

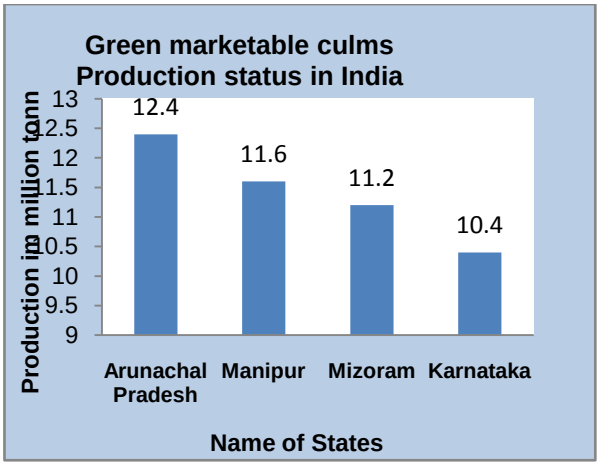


Fig.1 Green marketable culms production status in Indian state

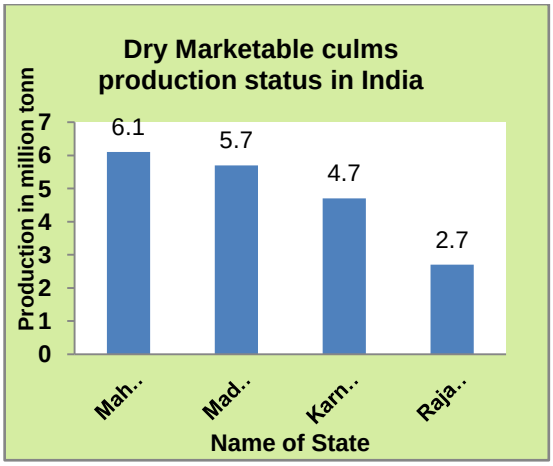


Fig.2 Dry marketable culms production status in Indian state

Bamboo species constitutes about 12.8% of total forest area of the country, out of this, nearly 28% area and 66 % growing stock present in the Seven sisters state (North Eastern States), followed by 20.3% area and 12% Growing stock in Madhya Pradesh and Chhattisgarh, 9.90% area and 5 % growing stock in Maharashtra, 8.7% area and 7 % growing stock in Orissa, 7.4% area and 2% growing stock in Andhra Pradesh, 5.5% area and 3 % growing stock in Karnataka and the balance is spread over in other states (Fig.3)

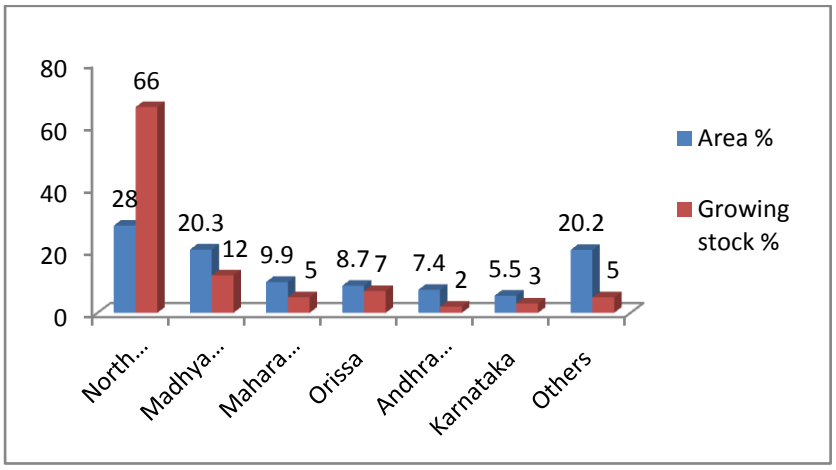


Fig.3 State wise availability of bamboo area and growing stock (in %) (http://nbm.nic.in/grow_bamboo.html).

In India maximum bamboo bearing area comes in deciduous forest of Central and South India and semi-evergreen regions of North-east and the tropical moist deciduous forests of North and South India. *Bambusa*, *Dendrocalamus*, and *Ochlandra* are three large major genera which have more than 10 species in each genus represents about 45 % of the total bamboo species found in India. (Sharma and Nirmala, 2015)

Madhya Pradesh is the second largest state to produce bamboo in India. In Madhya Pradesh, Balaghat district produces maximum 38 % of bamboo followed by 12% of Betul and 10.34% from Hoshangabad district in forest areas (Fig.4).

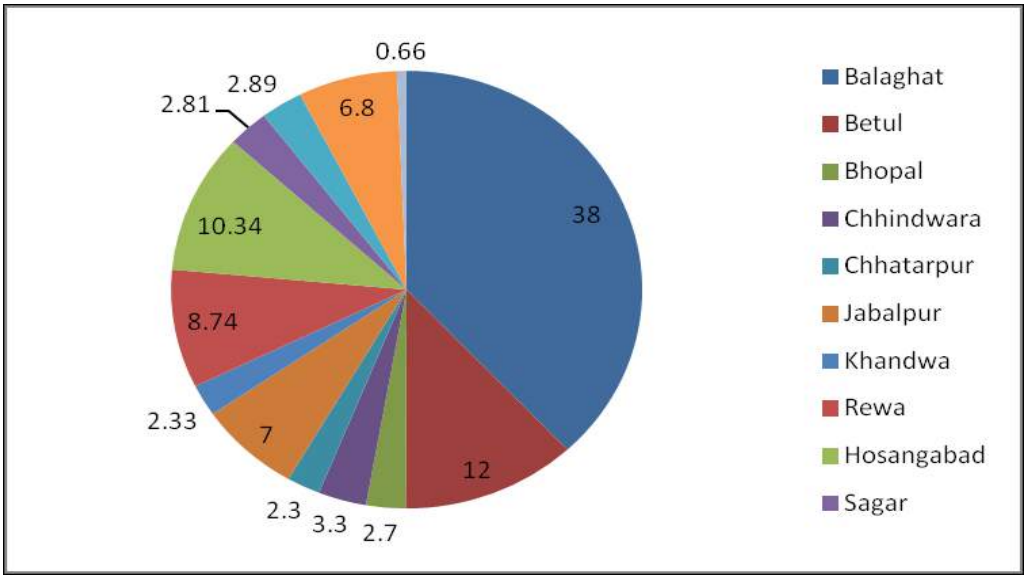


Fig.4: Bamboo diversity in Madhya Pradesh

The major Challenges area and strategy for enhancing green cover of India through bamboo species are:

Challenges

- Major challenge is limited area i.e. 329 m ha.
- Industrialization and Urbanization on agricultural land as well as degraded land.
- Increase in the demand of bamboos in the industrial sector and domestic uses due increasing population.
- Shifting cultivation in North-eastern region.
- Bamboo flowering and fruiting period (gregarious and sporadic flowering).
- Biotic and a-biotic pressure.
- Lack of protection against fire and grazing in bamboo forest area.
- Lack of knowledge of bamboo plantation and propagation skills among farmers.
- Lack of silvicultural practices of each bamboo species suitable for different site condition.
- Bamboo forest area getting less attention in forest working plan.
- Lack of awareness of bamboo based agroforestry models among farmer and grower.
- Low profit earning.

Strategy

- Rehabilitation of degraded land through bamboo forests.
- Increase bamboo cover in farmer's field through agro forestry programme.
- Improved clones of bamboos should be promoted for specific sites.

- Afforestation of wasteland with bamboo for sustains supply of bamboo.
- Promotion of bamboo plantation along the river bank and hilly track to control soil erosion as shown in Fig.7.
- Create awareness among the farmers/growers about bamboo species, its flowering and fruiting period, propagation technique, sustainable harvesting and management against insect-pest attack to maximize production of bamboo.
- Sustainable use of bamboo resources with using modern technology (Preservation practice and biological control) can enhance the economy.
- Industry on bamboo products should be established at least in each district.
- Training on manufacturing of bamboo handicraft items should be imparted to rural people by cottage industry.
- Marketing support to sale their products direct to the merchant to get additional income to the bamboo craftsmen.

Fig. 5. Bamboo along the road side

Fig. 6. Bamboo in Natural Forest

Fig. 7. Bamboo in farmer's field, Narai, Jabalpur (M.P.)

Fig. 8. Reclamation of rocky area through Bamboo plantation in Naga Ghati, Jabalpur (M.P.)

This species needs conservation on forest lands as well as in the farmer's field to enhance the green cover. Reason of over-exploitation of bamboo is lack of training on sustainable harvesting of bamboo within farmers and tribal communities and its flowering and fruiting behavior. Bamboo bearing area could be maximizing by introduction and domestication it on community forest area, wasteland, marginal land and farmer's field with proper land use systems. *Bambusa bamboos, Bambusa balcoa, Bambusa nutans, Bambusa tulda, Dendrocalamus hamiltonii, Dendrocalamus strictus and Bambusa vulgaris* are most common species of bamboo in India.

Initiative by the Government of India

Cabinet approved an amendment in the Indian Forest Act, 1927 exempting bamboo grown in non-forest areas from the tree list (as bamboo is woody grass), thereby dispensing with the requirement of felling or transit permit for its economic use. Now the farmer can cut and carry the bamboo anywhere in India for trading. The idea is to encourage bamboo plantation in farmer's field as agro-forestry component for sustain production.

Initiative by the TFRI, Jabalpur (M.P.)

The institute has developed bamboo based agroforestry models, tissue culture techniques for different bamboo species and value added products of bamboos for the promotion of bamboo sector. The Institute was already conducted different training programme of bamboo based training programme to develop skill development of bamboo artisans under Bamboo Technology Support Group (BTSG) programme since last 5 years.

Bamboo based agroforestry model developed by TFRI, Jabalpur (M.P.)

References

Bystriakova, N; Kapos, V.; Lysenko, I.; and Stapleton, CMA (2003). Distribution and conservation status of forest bamboo diversity in the Asia-Pacific region. Biodiversity and conservation, 12:183-184.

Chauhan, S.K and Kumar, L. (2005). Bamboo: an ideal species for agroforestry

in India. Asia-Pacific Agroforstry News 27:14.

Filhoes, A.P. and Badr, O. (2004). Biomass resources for energy in North-Easter Brazil. Applied Energy**, 77**: 51-67.

Hindustan Times (2017). UNIDO pegs NE's potential at Rs.5000 cr.: Dr. Harsh vardhan. Press news on 23rd November, 2017.

Lobovikov, M., Paudel, S., Piazza, M., Ren. H., and Wu, J. (2007) Non-Wood Forest Products 18 World bamboo resources, A thematic study prepared in the framework of the Global Forest Resources Assessment (2005), (Vol. 18). FAO.

Mandal, R. and Khanduri, S.K. (2004). Product diversification in bamboo. opportunities for sustainable development. Souvenir, 7th world congress, 27th Feb. to 4th March, 2004 held in Delhi.

Piliiere, E. (2008). Communicating Science through a dynamic website concerning the multiple uses of bamboo, Bioscience Horizones.1-14.

Sharma, M.L. and Nirmala, C. (2015). Bamboo Diversity of India: An update, 10th World Bamboo Congress, Korea 2015. Pp. 1-12.

India State of Forest Report (2011). Bamboo resources of the country, Forest Survey of India (Ministry of Environment & Forests), pp. 57-66.

India State of Forest Report (2015). Forest cover, Forest Survey of India (Ministry of Environment & Forests), pp. 34

Heavy outbreak of mango leaf webber, *Orthaga euadrusalis* Hampson on mango trees in TFRI campus, Jabalpur

P.B. Meshram and Jagruti Roy
Forest Entomology Division
Indian Council of Forestry Research and Education, Ministry of Environment, Forest and Climate Change
Tropical Forest Research Institute
P.O.RFRC, Mandla Road, Jabalpur- 482021
E mail: meshrampb@icfre.org

In India, mango accounts for 22.06% of total area under fruit crops, making it the largest producer of mango in the world. It contributes 53.63% of total mango production. However, the productivity is affected by the climatic condition, diversity of associated pests and diseases (Vergese, 1998).

The Tropical Forest Research Institute (TFRI), Jabalpur has carried out roadside plantation of local mango species in the campus during 1995-96. Recent survey was conducted during July-October, 2017. The mango trees were attacked by various insect pests like scale insect, mealy bugs, fruit fly, leaf webber, stem borer, root borer, fruit borer, fruit sucker, bark eating caterpillar, and termites. Among these, it was observed that the trees were severely attacked by leaf webber with about 60-70 per cent incidence. These larvae were collected and reared in laboratory on the leaves under the prevailing environmental conditions until pupation. These pupae were kept till emergence of the adult moth. The insect was identified as *Orthaga euadrusalis* Hampson (Pyralidae: Lepidoptera) (Fig. 3). The brown colour larvae bind leaves, feed within the web, defoliate resulting into drying of leaves with burnt appearance (Fig. 1-2). Due to this characteristic feeding behavior, the heavily infested trees give a burnt look. The larve descend from the tree with the help of silken thread for pupation, which takes place on the ground or on the dead leaf. It is one of the major pests responsible for low productivity. The severe infestation of this pest may result in complete failure of flowering (Vergese, 1998). The webbing of terminal leaves and tender shoots with several larvae found inside. Larvae initially scrap on the terminal leaves within the web (Kavitha et al., 2005). Reddy et al. (2001) also screened mango cultivers against this insect pest. It is widely distributed in different agro-climatic zones of India, and gained the status of serious pest in UP, UK, and AP. (Singh et al., 2006). Mango leaf webber infests over wide range of mango varieties and cause damage before mango season. After flowering, the inflorescence may also be webbed along with the leaves and the larvae feed on inflorescences resulting in poor fruit setting. The incidence of this insect pest is prominent in neglected orchards.

This insect pest can be controlled by the application of the following methods:

- Removal of overcrowded leaf crowns and criss-cross branches to allow enough air and sunlight.
- Manual or mechanical destruction of webs with long hooked bamboo

poles can curb the spread of the pest to some extent.

- Pruning infested shoots and burn can helps down the pest population.
- Parasite like *Brachyameria* can be used against this insect pest.
- Insecticide imidaclopride 17.8 SL@.03% (1.7 ml/per lit of water) can be sprayed against this insect pest.

References

Kavitha, K., Vijaya Lakshmi K. and Anitha V. (2005). Mango leaf webber, *Orthaga euadrusalis* Walker (Pyralidea: Lepidoptera) in Andhara Pradesh. Insect Enviroment, 11 (1): 39-40.

Singh, R., Lakhanpal, S.C. and Karkara, B.K. (2006). Incidence of mango leaf webber, *Orthega euadrusalis* (Hampson) in high density plantation of mango at Deharadun, Himachal Pradesh, 11(4): 178-179.

Vergese A. (1998). Management of mango leaf webber. A vital package for panicle emergence, Insect Enviroment, 4(3): 7.

Reddy, C., Harihara Prasad, P. Rajendera, and Umamaheshawari (2001). Screening of mango cultivars against the leaf webber, *Orthaga exvinacea* Hampson (Pyralidae: Lepidoptera), Ind. J. Plant Protection, 29 (1&2): 118-111.

1

2

3

Figs: 1. Mango tree damaged by leaf webber; 2. Web leaves; 3. Larva of *Orthaga euadrusalis*

Commiphora wightti: A plant with potential healing powers

Neelu Singh
Non- wood Forest Produce Division
Tropical Forest Research Institute
Indian Council of Forestry Research and Education, Ministry of Environment, Forest and Climate Change
Jabalpur-482-021

Commiphora wightii (Arnott.) Bhandari (Burseraceae) is a small tree or shrub found naturally growing in the arid and semi-arid regions of India, Pakistan and tropical regions of Africa. In India, it is found distributed in Rajasthan, Gujarat, and Madhya Pradesh and Karnataka states. It is commonly known as "Guggul" or "Indian Bdellium" due to the presence of aromatic steroidal ketonic compound Guggulsterone in vertical rein ducts and canal of barks. Circular or slant incision are made on the main stem/secondary branches from which a pale yellow fluid exudates, which is quickly solidify to form agglomerates of tears of golden brown or reddish brown colour.

Fig.1. Guggal plant

The plant exudes a gum- oleoresin (known as Guggul), mainly contains gum (29.3%), resin (61%) and essential oil (0.6%). Essential oil contains mainly myrcene, dimyrcene and polymyrcene (Dutt et al., 1942). The gum fraction contains arabinose, D-galactose, L-flucose and D-galactopyranose (Bose and Gupta., 1964). The resin fraction contains bioactive molecules- guggulsterones-E&Z, guggul sterols etc.

Fig.2. Oozing of oleo-gum resin

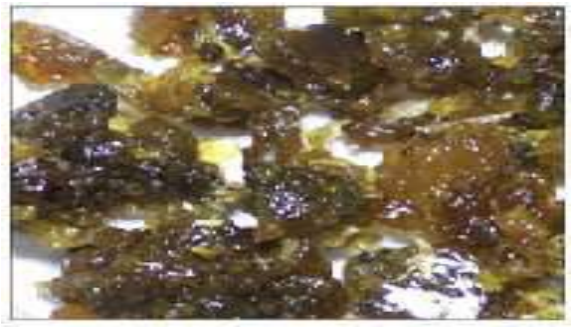


Fig.3. Oleo-gum resin of *C.wightti*

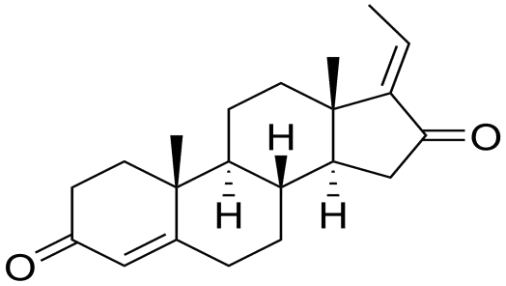


Fig.3 Guggulsterone - E

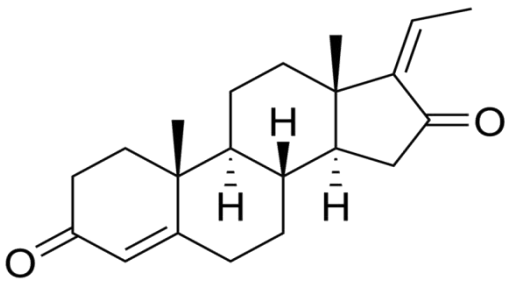


Fig.4 Guggulsterone - Z

Guggul occupies an important place in lndian traditional System of Medicine i.e. Ayurvedic medication since ancient time, its medicinal and therapeutic properties are well documented in the Vedas, the holy scriptures of India. The detailed uses of guggul as a drug is given in Charaka (1000B.C.), Sushrut Samhita (600 B.C.), Vaghbata (17th century A.D.) and various Nighantus written in India between 12th and 14th centuries (Kumar and Shankar, 1982; Satyavati, 1991). It is used as an anti-inflammatry, antispasmodic, expectorant, hypoglycemic, diuretic, antiseptic, thyroid stimulant, anthelmintic, depurative, vulnerary, aphrodisiac stimulant, liver tonic etc., Guggul has also been used to treat hypercholesterolemia, hypertension, bronchitis, gingivitis, hay-fever, hysteria, laryngitis, obesity, arthritis, inflammation and skin diseases (Satyavati, 1988, Kulhari, 2012). Recent clinical analysis revealed that the isomers- E and Z guggulsterones are responsible for the biological activities of oleo-gum resin, guggul (Urizar and Moore, 2003; Wang et al., 2004). Guggulsteron and guggulipid have been demonstrated to reduce risk of cardiac function in clinical studies (Ulbrich et al., 2005) and also inhibits platelet aggregation and provides protection from myocardial ischemia in rats (Mester et al., 1979; Chander et al., 2003) due to antioxidant property.

Guggul is known as a yog-vahi rasayana which shows synergistic action and improves the action of other herbal medicine that are used in its combination. More than 25 drugs in combination with other herbal medicines are available in the market. Some important formulations containing Guggul as an ingredient are:

- Triphala Guggul – for joint pain, arthritic conditions, muscle aches, rheumatism and weight loss.
- Yogaraja Guggul – for nervous system disorders
- Lackchhadri guggulu- for hemorrhoids
- Kaishora Guggul- for skin diseases, blood purification, helps in elimination of toxins from the joints, healthy metabolism
- Mahayograj Guggul – for gout and rheumatism
- Navaka Guggul – for weight loss and rheumatoid arthritis.
- Singhnad Guggulu - for lack of appetite, dysentery, spasm digestion, gout.
- Saptavinshati Guggulu- for worm infestations in the body.
- Gokshuradi Guggulu - for all kinds of urinary troubles including stones
- Kanchanara Guggulu - for deep-seated kapha imbalances, supports healthy tissues including muscles, fat and bones as well as the thyroid and the lymphatic system, useful in Tumors and Goitre.
- Laxadi Guggul- for fractures, osteophytes removal, to enhance calcium deposition on ones.

Ayurvedic firms associated with the guggul based preparations are Daber India Limited, Sri Baidyanath Ayurvedic Bhawan Limited, The Himalayan Drug Company, Zandu Pharmaceuticals, Charak Pharmaceuticals, Vicco Laboratories and Diviya Pharmacy etc.

Guggul is an important ingredient of Havan samagri. It is also used in incense, lacquers, varnishes, ointments and in perfumes. Guggal is tapped by local people for extraction of guggul. They

make deep incisions on stem using sharp instruments and chemicals. Excessive tapping adopting unscientific methods for oleo-gum resin has led to extensive depletion of the species from the nature making the plant vulnerable. *C.wightii* is assigned to the Data Deficient category ver.2.3 (1994) of Red data Book of IUCN, the Government of India has included it under RET (Rare, Endangered, Threatened) category. Presently, only limited wild populations exist in the states of Madhya Pradesh, Rajasthan and Gujarat. Annual guggul production in India was about 51 metric tons during 1963-64 (Atal et al., 1975) which has diminished considerably with dwindling plant stand. According to an estimate, the demand of Guggul is 1000 MT but India produces only 100 MT against its requirements. The Government of India has banned the export of the gum due to its Increasing overexploitation and high market price in the International trade. In the present scenario, due to the side effects of allopathic medicines, the value of natural products is increasing day by day. Studies on *C. wightii* proven its tremendous potential in controlling several diseases. Therefore, there is urgent need to find out suitable measures for conservation of this wonderful medicinal plant on sustainable basis.

References

Atal, C.K. (1975). Source of guggul in Indian system of medicine. Econ. Botany, 29: 208-218.

Bose, S. and Gupta, K.C. (1964a), Structure of Commiphora mukul gum, part 1, Nature of the sugar present and the structure of the aldobiouronic acid. Indian J Chem.; 2: 57-58.

Chander, R., Khanna, A.L., and Kapoor, N.K. (1996). Lipid lowering activity of guggulsteron from Commifera mukul in hyperlipaemic rats. Phytotherpy Res. 10:508-511.

Dutt, A.T., Ghosh, S. and Chopra, R. N. (1942). The chemical investigation of the gum resin of *Balsamodendron mukul*. Indian J. Med. Res. 30(2): 331-334.

Kulhari, A., Sheorayan, A., Saxena, N., Mohan, C., Mangal, M. and Chaudhury, A. (2013). HPTLC analysis of guggul sterone isomers in *Commiphora wightii* (Arn.) Bhandari: an endangered oleo-gum resin species heading towards extinction. Genet. Resour. Crop.Evo. l60:1173-80.

Kumar, S. and Shankar, V. (1982.) Medicinal plants of Indian desert: *Commiphora wightii* (Arnott) Bhand. J Arid Enviro.5:1-11.

Mester, M., Mester, L. and Nityanand (1979). Inhibition of platelet aggregation by Guggul steroids. Planta Medica. 37:367.

Satyavati, G.V. (1988). Gum Guggul (Commiphora mukul): The success story of an ancient insight leading to modern discovery. Indian J. Med. Res. 87: 327-35.

Satyavati, G.V. (1991). Guggul lipid: a promising hypolipidimic agent from guggul (*Commiphora wightii*) In: H. Wagner (Ed.), Economic and medicinal plant research, Academic Press, Harcourt Brace Javanovich, London, Vol.4, p.47-80.

Ulbricht, C., Basch, E., Szapary, P., Hammerness, P., Axentsev, S., Boon, H.,

Kroll, D., Garraway, L., Vora, M. and Woods J. (2005). Guggul for hyperlipidemia: a review by the Natural Standard Research Collaboration. Complementary Therapies in Medicine, 13(4): 279-290.

Urizar, N.L. and Moore, D.D. (2003). Guggulipid: a natural cholesterol-lowering agent. Annual Review of Nutrition .23, 303–313.

Wang, X., Greilberger, J., Ledinski, G., Kager, G., Paigen, B., Jurgens, G. (2004). The hypolipidemic natural product Commiphora mukul and its component guggulsterone inhibit oxidative modification of LDL. Atherosclerosis.172, 239–246.

Know your biodiversity

Swaran Lata and Preeti Kaushal

Himalayan Forest Research Institute (HFRI)
Indian Council of Forestry Research and Education, Ministry of Environment, Forest and Climate Change
Shimla (Himachal Pradesh)

***Quercus ilex* (Brey Oak)**

Quercus ilex is small or medium size tree. It is commonly known as Holly oak and Holm oak. It is also known as *Irru*, *Irri*, *Irranh* and *Brey*. *Quercus baloot* and *Quercus rotundifolia* are its synonyms. It belongs to order Fagales and family Fagaceae. It is very slow growing tree and its lifespan is about 400 years. It is typically xerophytic species, often forming low scrubby growth with spinous leaves and growing on dry, rocky and hot slopes. Its xerophytic habit is exhibited by its capacity to produce root suckers. It is resistant to both drought and frost.

It has wide distribution, occurring in different soils and climates and showing considerable variation in different localities. It prefers moist clay, loam and sandy soil for its growth. It is native to Mediterranean region and found in France, Spain, Italy, Portugal, Corcica, Greece, Syria, Morocco, Algeria, Tunia, Pakistan and India. It is cultivated in England. In India it is found in Western Himalayan regions of Himachal Pradesh, Uttarakhand and Jammu-Kashmir at altitude of 900-3000 m.

In Himachal Pradesh it is found over a very small area in the dry zone of Kinnaur beyond the reach of monsson rains in Kilba, Kailash and Chini ranges upto 3000 m. It is often found associated with *Acer sp.*, *Cedrus deodara*, *Celtis australis*, *Fraxinus xanthoxyloides*, *Olea cuspidata*, *Pinus gerardiana*, *Pinus wallichiana*, *Sorbaria tomentosa*, *Daphne oleoides*, *Lonicera quinquelocularis*, *Berberis lycium* and *Artemesia maritima.*

It grows up to 25 m. The crown is broad, domed, with ascending branches. Young shoots are stellate-pubescent and appears in the month of March and April. Petioles are 3-4 mm long. The bark is brownish-black and shallowly cracked into small, square, thin plates. Leaves coriaceous, oblong-ovate to obovate, elliptic or suborbiculate, 3-7cm long, entire or spiny-toothed, upper surface green, lower pale green, soft white haired beneath. Leaves persist for less than one and half years. Flowers are of two types male and female. Male Flowers yellow, in catkins, 3.3-5 cm long, lax, pubescent. Stamens are 5-7 in number. Female Flowers are minute, usually in two or three, sessile on 2-4.2 cm long peduncles.

Pollination occurs by the wind and after the pollination female flowers are converted into Acorns. The fruit is known

as acorn which is 1.5-2cm long and brown in color. Acorns are oval or rounded in shape. There is little or no growth in the young acorns during the first season and they remain small until April-May of second season after which they develop rapidly. The acorn ripens in the month of October and usually two or three in number on a common peduncle. Its one third parts is enclosed in a light green cupule with appressed scales, and hanged on short peduncles. Mature acorns fall during the period November-January.

As compared to other oak species this tree is less susceptible to pest and pathogens. The larva of *Stromatium barbatum* bores in dry wood and the larva of *Dorysthanes hungeli* bores in stumps and in dead or living roots.

Wood is very hard, heavy and durable. Wood is used for making agricultural implements, tool handles and also used as fuel. It also yields good firewood and charcoal. The leaves and branches lopped for fodder and prickly branches used for fencing. Bark is used for tanning. Acorns are edible and also used in preparation of industrial alcohol. Acorns also yield edible oil and residual meal used as feed. Beside this it is favorite food of monkeys. Galls have medicinal properties used to cure dysentery, diarrhea and haemorrhage and also used to dying the hairs and in market it is sold as name *'Maju'*. In ancient Greece the leaves of the holm oak were used to tell the future and they were also used to make crowns to honour people. The acorn was seen as a sign of fertility and wearing acorn jewellery was believed to increase fertility. In Greek lore, the primitive tribes of Arkadia were said to have lived on a stable diet of acorns.

In the Western Himalaya *Quercus ilex* assume considerable conservation significance as they are providers of numerous ecosystem services viz. conservation of soil, water, native flora and fauna and also serve as lifeline for the local communities. This species is associated not only with agro-ecosystems but also with the life support system of the inhabitants of the hills in this area. Steady increase in human population, tourism, over-exploitation, widespread logging, overgrazing, removal of leaf and wood has been responsible for the degradation of this species. Beside these, livestock grazing also affecting small regenerating plants. Hence conservation of this valuable species would not be possible without the active participation of the local people.

Phoenicurus leucocephalus

Phoenicurus leucocephalus is commonly known as The White-capped Redstart or The White-capped Water Redstart. It belongs to order Passeriformes and Family Muscicapidae. The species was earlier placed in the monotypic genus of *Chaimarrornis* but now moved to *Phoenicurus* on the basis of molecular phylogenetic studies. The vernacular name of The White-capped Redstart is *Hiun chiru*. The generic name of this species is derived from the Greek word '*kheimarrhos'* meaning "torrent" and '*ornis'* meaning "bird".

The bird is found in the Himalayas from extreme northwest to extreme North east of the Indian Subcontinent and Southeast Asia, as well as some adjoining areas. The species ranges across Afghanistan, Bhutan, Cambodia, India, Laos, Myanmar, Nepal, Pakistan, Tajikistan, Thailand, Tibet and Vietnam. Its natural habitat is usually in temperate forests. In summer they range between 6000 to 16000 feet elevation. In winters this Redstart comes down a quite low and is observed on 900-1100 meters high.

White-capped Redstart is slightly bigger in size than a sparrow and a bright colored bird. The Robin like Bird is black from above and bright chestnut colored from below with metal glance but not well appreciable from distance. The characteristic feature of the bird is the presence of glistening snow white cap and a bright chestnut tail ending in a black band. Sexes are almost alike but on carefully contemplation males have larger white pattern on top of the head and brown red spots under the wings. The bright metal glance of the black feathers of breast, neck and craw is observed on males only. The abdomen, rear part of the back, upper tail and large part of the tail are reddish in color. Birds often up and down the tail like Himalayan Ruby throat or Blue throat.

In contradistinction to other redstarts White-capped Redstart lives only near heavy mountains rivers and never far depart from rivers on summer and winter both. Autumn migration begins in early month of October when Redstarts depart from breeding area on account of becoming of adverse live conditions. In winter season Redstarts found living single or in pairs whereas in spring time White-capped Redstart departs these wintering places. Spring migration seen on end February to early March and depends on climatic conditions of individual years. Hereby vertical migration of White-capped Redstart on mountain rivers valleys seen from 800-3000 meter high and horizontal migration sometimes may be on a quite large distance.

The bird sings on breeding time only. Common breeding areas of these birds are quite bushing coasts of strong mountain rivers and affluent with rock and other solid slopes. Generally it stands aback from wide river valleys and prefers narrow rock hollows with different size stones. Nesting begins quite late in the end of May. One of the main causes of it is the hard climatic conditions and the large banks of snow in the breeding areas of Redstarts. This redstart breeds in the month of May and July-August. The nest is a bulky cup is fairly deep and made with grass, rootlets and moss mixed with leaves etc. and lined with wool, hair and roots. It is based in a hole of rock, in a hollow in a bank. The nest is placed in hole, in rock, tree, and bank or inside the walls, under stones or tree roots. Only female incubates about two weeks and same time the juveniles stay in the nest. First chicks appear at first decade of July but the most part at the middle of this month. After juveniles fledging White-capped Redstarts a few time lives by broods. On September these broods decay. Generally White-capped Redstarts have one brood per summer. The special character of molting of White-capped Redstart and other high mountains resident birds is intensity and short term of molting. At molting period the adult birds completely loose the use of flight.

Its food consists entirely of aquatic insects which are picked off the water as they float past or when cast up high and dry by a ripple. It also makes short aerial sallies after winged insects in the manner of a fly catcher. In summer season they eat ants, grasshoppers, little spiders, flies, beetles and other insects whereas in winters they eats berries of hawthorn, wild cherry and other fruits and berries of trees and bushes vegetating on the rivers coasts. Pantophagy (a diet which consist of variety of food) is specific feature of this bird.

Presently the population of these Redstarts is suspected to be stable in the absence of evidence for any declines or substantial threats. This species yet has an extremely large range. A population trend also appears to be stable and hence they do not approach the thresholds for Vulnerable under these criterions and for these reasons the species is evaluated as Least Concern by IUCN Red List. Though *Phoenicurus leucocephalus* is not globally threatened but it is uncommonly seen in mountains of Central Asia which is a matter of concern. These birds are facing number of threats such as increasing pollution, global warming, human interference etc. may led to serious decline in its population. These Redstart birds may come under the category of least concern according to present situations but there conservation is mandatory and appropriate measure should be taken before the bird comes under threatened category.

Reference

Singh, G. and Rawat, G. S. (2012). Depletion of Oak (*Quercus* spp.) Forests in the Western Himalaya: Grazing, Fuelwood and Fodder Collection, Global Perspectives on Sustainable Forest Management, Okia Clement Akais (Ed.), ISBN: 978-953-51-0569-5, InTech.

Chowdhery, H.J. and Wadhwa, B.M. (1984). Flora of Himachal Pradesh. 3 Volumes. Flora of India Series 2. Botanical Survey of India, Howrah, Calcutta. 860 pp.

Brandis, D. (1921). Indian Trees. An account of trees, shrubs, woody climbers, bamboos and palms indigenous or commonly cultivated in the British Indian Empire. Constable and Company Ltd., London. 767 pp. (Reprinted many times by International Book Distributions, Dehradun, India). Brickell, C. (Editor-in-Chief) 1960, 1996. The Royal Horticultural Society A-Z Encyclopedia of Garden Plants. Dorling Kinder sky. London, New York, Stuttgart, Moscow, 1080 pp.

Ali, S. (1979). Indian Hill Birds. Oxford University Press. pp. 59-60.

Besten, J.W.D. (2004). Birds of Kangra. Moonpeak Publisher. pp. 126.

Grewal, B. (2000). Birds of the Indian Subcontinent. Local Colours Limited. pp. 103.

orientalbirdimages.org

www.hbw.com

www.iucnredlist.org

www.oiseaux-birds.com

Published by:

Tropical Forest Research Institute
(Indian Council of Forestry Research & Education)
(An autonomous council under Ministry of Environmnet, Forests and Climate Change)
P.O. RFRC, Mandla Road
Jabalpur – 482021 M.P. India
Phone: 91-761-2840484
Fax: 91-761-2840484
E-mail: vansangyan_tfri@icfre.org
Visit us at: http://tfri.icfre.org or http://tfri.icfre.gov.in